THE

ELECTRICAL REVIEW.

VOL. XLIX. DECEMBER 13, 1901. No. 1,255.

CONTENTS:

	PAGE
Electric Traction	957
Brakes	958
The Electrification of Our Railways	959
Economy in Plant for Traction Stations	961
Shallow Underground Tramways	962
Correspondence:—	
Tramway Specification	964
London Subway Tramways	964
Telephone Tariffs	965
Business Notes	966
Sprague Multiple Unit System (*illustrated*)	967
The Electric Train Control System on the Great Northern and City Railway (*illustrated*)	972
The Westinghouse Electro-Pneumatic System for the Control of Electric Trains (*illustrated*)	975
The Electric Lifts on the City and South London Railway (*illustrated*)	977
The Tramways and Light Railways Exhibition	980
Machinery and Equipment for Electric Traction Systems (*illustrated*)	981
Traction Notes	1016
City Notes	1021
Traffic Receipts	1022
Stocks and Shares	1022
Share List of Electrical Companies	1023
Market Quotations	1024
Accumulators and Electric Traction Systems	1025
Electric Tramways on the Conduit System	1026
Shallow Underground Tramways	1026

THE

UNIVERSAL ELECTRICAL DIRECTORY

1902 Edition

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ELECTRIC TRACTION.

TWENTY years ago we recorded in the columns of the ELECTRICAL REVIEW the opening of the first electric tramway ever laid down in the United Kingdom. It was propelled by means of Faure batteries, was the property of the North Metropolitan Tramways Company, and ran in their Leytonstone yard. Then, as now, there was the customary invited party of visitors, and we referred to the amazement of the inhabitants in Union Road at seeing a tramcar "full of people travelling at the rate of seven or eight miles an hour without any visible motive power" along a quarter-mile route. Not long thereafter the Blackpool conduit tramway on the Holroyd Smith system—the pioneer conduit line of the whole world—began its chequered career.

Electric traction was then but cutting its first teeth, and the severity of its infantile troubles, unduly prolonged as they were, retarded full and healthy development.

Many inventors have since laboured untiringly in the field of battery traction, and something practical has been accomplished; but the company which was the first to inquire into the merits of electric traction, stands to-day pretty well where it was in 1882, in fact, it bids fair to be one of the last to change over from horse to electrical haulage.

As regards conduit lines, there has been a 20 years' lull, and little of interest has happened here save the conversion of the Blackpool system; but engineers have, meanwhile, been at work upon the problem, with the result that we are at this very moment in the midst of most important developments—Bournemouth being committed to a side slot section, and London to a centre slot, as we mention elsewhere.

The overhead trolley came along at the psychological moment and filled the gap most satisfactorily. It has its limitations, no doubt; but we are not like some who have fond imaginings that it has not long to stay. Its supersession is not an event of the next few years, we imagine. None can fail to recognise the great benefits which have followed in the trail of the trolley wherever it has been allowed free scope; and how true it is that our tramway officials and local authorities do now appreciate its good points is evidenced by the millions of pounds which are yearly being spent in practically applying the principle in all parts of the United Kingdom.

This great development is belated, it is true, but the causes of the delay do not call for inquiry in this article, as they have been reiterated almost beyond endurance. What we, in our capacity of correct chroniclers of electric traction progress, wish to do at the moment, is to cover matters as they actually exist at the end of this year 1901, and in the following pages of this Electric Traction Trade issue of the ELECTRICAL REVIEW we have endeavoured to place before our readers matter of immediate practical service to them. The material which we have collected together should be of especial value to those who are daily and directly engaged in

the electric traction industry, and to the many others who are certain to specialise in this great section of electrical engineering and enterprise during the next few years. A careful perusal of the contents of this issue will serve to show what our manufacturers are prepared to do in the equipment of power stations, the laying out of permanent way, the supply of rolling stock, and the construction of overhead or underground work, whether for tramways, light railways, or railways.

As Mr. Dawson very clearly indicates in his timely article on the "Electrification of Railways," the next few years will witness some important developments in this direction, and the descriptions which we give of the several systems of train control and operation are worthy of careful study. It is of interest to remark here that—so far as a Board of Trade arbitrator can settle it—the controversy as to the electrical equipment of the Metropolitan and District lines has come to an end, and Mr. Yerkes has scored. We venture to hope that as much energy as has been shown in the discussion will be employed in carrying out actual operations on the railways.

A striking evidence of the interest which the Great Eastern Railway Company, perhaps the most enterprising of all English railways, is taking in the subject, is shown by the fact that recognising the important part that electricity will play in railway traction in the near future, Lord Claud Hamilton, on behalf of the company, has promised a donation of £1,100 towards the formation of class-rooms and electrical laboratories at the Mechanics' Institute attached to the Stratford works, so that all the men employed there may have an opportunity of a thorough electrical training.

We do not think that an apology is due to any of our readers for devoting this particular issue of the Electrical Review almost exclusively to electric traction matters. How vitally important a branch—interconnected with other sections—of electrical engineering they represent, is appreciated by all who have any interest in the welfare of things electrical. By those in the Colonies, where so much new ground will shortly be cut by the tramway man, we believe that everything of the kind is eagerly scanned, and we further indulge the hope that thousands of readers at home will find our work worth placing ready to hand for frequent reference for several months to come. To all who have in any way assisted us in the gathering together of this volume of material, we tender our thanks.

BRAKES.

One feels that electric cars have been out-growing their brake-power. For a year or so much more attention than formerly has been given to this most important point; but the continual occurrence of accidents, due to the inability of the driver to check his car effectively, proves that this attention has not been universal; although one must admit that the best brake in the world may be useless when handled by an incompetent, or a timorous, driver.

It cannot be necessary to point out that it is the best policy to get the best brakes, however expensive they may be. Accidents have a way of being more expensive than any part of the equipment. In that relation it is open to one to express surprise that the insurance companies, which undertake traction risks, do not insist on the application of certain safeguards against accidents before they issue any policy. Is it that insurance competition is so keen? If so, things financial have a way of equalising themselves—although we know that one or two companies have been bitten badly already—and we must suppose that the average premium rate is higher than it used to be, pinching most unfairly those enterprises that have taken all reasonable precautions. Like the Boiler Insurance Companies, they should maintain a staff of competent inspectors, who would examine the cars periodically to assure themselves of their efficient maintenance, so far as the companies themselves were concerned. So would both premiums and accidents be reduced.

We have come to the conclusion that the best life-guard is a good brake, handled by a good driver; it is not impossible to obtain, or to make, the latter.

There are only two kinds of brake. The more common retards the car by acting on the wheels or axles, either directly or indirectly; the other is the slipper, or track, brake, retarding by friction between the rails and blocks of wood or metal pressed thereon. Probably every car in the world is fitted with wheel blocks; but coming into fashion more and more, as an addition to the wheel brake, is the electric brake, which uses the energy of the moving car as the retarding force, dissipating that energy in heating resistances and motors, rather than in heating up and wearing out wheels and brake shoes. Another form of electric brake is of the frictional disc type, combining mechanical and electrical friction.

Unfortunately, the efficiency of all those brakes which act through the rotating parts is dependent on the rotation of these parts, their rotation again depending on the coefficient of friction between wheel and rail. This coefficient varies most abominably. The best rail for braking is the rail washed clean by heavy rain; the worst is that on which much dust lies when a soft rain falls. In the latter case a layer of thick grease is formed which is not expressed by the weight of the car; the coefficient of friction is then that of two lubricated surfaces, and some difficulty may be found in stopping the car without skidding the wheels. Of course, every car carries sand, for use on such occasions, but it is difficult to get every driver to use it properly. Good drivers do not meet with accidents; it is only the undesirable ruck who skid their wheels and collide with things. Now, the track brake does not care whether the wheels are revolving or not. It is independent of them, obtaining its pressure from the dead weight of the car.

Every car working on grades exceeding 1 in 20 should be equipped with track brakes.

We should like to see one of two combinations on all cars; the first being a mechanically operated slipper, with a rheostatic, or a disc brake, supplied with current from the motors; preferably the disc, which does not treat the motors so hardly as the other. In this case the wheel-brake would not be fitted, and much complication on the truck (especially on a bogie, and more especially on a maximum traction bogie) would be avoided.

The second combination would consist of an electro-magnetic slipper-brake, and the ordinary wheel brake, as it would not be wise to put all one's eggs in one basket by fitting a second electric brake supplied with power from the same source.

The first combination appeals to us more than the second. It will be a good day for cars when the hand-operated wheel-brake is abolished. Whenever the driver puts on the wheel-brake he is as one stringing a bow, the wretched car-body being the part bent. This strain is aggravated in single-truck cars with a long overhang.

The ideal driver wishing to slow up or to run downhill at an even speed will pull on his slipper brake, and will obtain the requisite additional retardation with his electric brake. His work is much reduced, and control is obtained more easily and more gradually.

This ideal man, however, does not think, as some do, that it is impossible to skid the wheels with an electric brake. Far from it. Although the wheel-brakes may be scrapped, there is still use for sand-boxes. If the slipper is on, even greater care must be used when applying the electric brake, as so much weight has been transferred from the axles to the slipper.

There is a distinct tendency nowadays to rush from too few brakes to too many. There are many brakes on the market, but it is not necessary to put them all on one car.

Throughout these remarks no mention has been made of the short-circuiting, or emergency, brake. Whatever else is fitted, connections should be made for *that* on the controller. With the rheostatic brake it is found on the last backward notch of the controller. Its chief beauty, and its chief drawback, lie in its quickness of manipulation and operation. There is no gradation of power; for at high, and also at moderate, speeds the gradation due to the building up of the motor fields is so steep, that application and full effect are practically simultaneous. That is the worst of it; the skidding point is reached, even on a clean rail, just when skidding is desired least. Under all circumstances sand should be dropped before the emergency brake is applied, and while it is in action.

Shallow Underground Tramways.

It seems to us that the report of Messrs. Rider and Baker, which we reprint in another column, is well written, and the conclusions in the main sound. We note that the estimate makes no provision for the cost of providing subways for pipes, or the cost of removing them. It is to be remembered, however, that the estimate is based on the American figures, and that no pipe subways were provided over there. We share the surprise of the writers of the report at the omission, but we do not regard the absence of any figures for the pipe service as being of serious importance, for the reason that a charge will be made for the use of the pipe room, which will, therefore, become a source of income, whatever the cost may be.

We feel like questioning a little the reference to the quietness of the subway. True, they speak of it as "comparatively" quiet, but our recollection is, that in the busiest parts of the Boston subway, the noise was very trying to the nerves, though it is quite true that above ground there was no noise at all; in point of fact, Tremont Street is very much quieter than Trafalgar Square. If the report has a fault, we think it arises from the comparison between the shallow subway and the "Tube." The authors talk of the little likelihood of people going down and coming up lifts for the sake of running a few hundred yards, as if the use of such service were limited to the distance between two stations. Our own impression would be that there is room for both services, and that no one ought to question the utility of either, and we do not think that too much importance can be attached to the advantages of speed where tramcars are running on a route limited entirely to themselves, instead of on the surface ground, where the traffic is shared by other vehicles and by foot passengers.

THE ELECTRIFICATION OF OUR RAILWAYS.

By PHILIP DAWSON.

Some years ago the writer stated in the columns of the Electrical Review that in the near future electricity would play a very large part in the operating of our main line railways. So far, the only thing that has been done in this line is the building and extending of the tube railways.

The question of the electrification of steam lines can be approached from two very different sides. The same point of view was taken by Mr. Langdon in his paper before the Institution of Electrical Engineers, and by Major Cardew in his Cantor lectures; in both cases the advantages of working an entire railway system by electricity were considered.

Such an undertaking would present many novel features, and the lack of sufficient data, gained from practical experience would make it of a highly experimental nature.

It has yet to be practically demonstrated what are the advantages of electricity, considered from the point of view of financiers and managers, when dealing with heavy high-speed trains running long distances without stopping. That there may be cases even now where conditions are such as to render the use of electricity for this kind of traffic advisable, nobody will contest; but it is the exception and not the rule. It may be urged that for high-speed railways, on which it is proposed to run at a speed of 120 miles an hour or more, electricity alone is available. This is the case, but it is questionable whether such high speed lines are commercially possible. The amount of power which will be required to drive trains at such high rates of speed against contrary winds, will be very large, and will have to be paid for by the travelling public. The capital cost of such a line must necessarily be abnormally high, and at present the electrical equipment available for this class of work is still in the experimental stage.

A few years will greatly increase our knowledge in this branch, and the results which will be obtained on the military line between Berlin and Zossen will be looked forward to with interest. But even if these experiments prove successful in every way, the principle of long-distance lines will not be solved, as the problem of handling long and heavy trains is not being approached. The experiments now being carried out are made with single motor-cars.

The electrification of our railways may be looked at from another point of view, which ignores the high speed main line trains, and deals exclusively with the heavy suburban traffic. This is a view of the question which is being seriously considered by some of our largest railway companies; it introduces no new problems, as a large amount of experience has been obtained in running a large number of trains in rapid succession over short distances, with numerous stops. Standard apparatus, manufactured on a very large scale by well-known firms, is available, and there remains little, if anything, which is experimental. The table on p. 960 fixes some data relative to the work of this class which has already been carried out.

In such a proposition the most important point is to get as high an acceleration as possible, with due regard to the comfort and safety of the passengers. It is evident that in short-distance runs, if the acceleration can be increased, the average speed of the train is increased, and with the same factor of safety as regards running, the number of trains can be increased. This, of course, is on the assumption that no slow trains are sandwiched in between the electrically-driven ones. The maximum acceleration for traffic of this sort, which seems to be possible on steam railways, is 9 in. per second per second. Electrically it is quite feasible (although not advisable either economically or for reasons of safety) to exceed an acceleration of 24 in. per second per second.

The trains, when run electrically, can be made double-ended; that is to say, with a motor-car at each end of the train, so that they can be run indifferently in either direction, thus doing away with the labour and time of shunting the locomotive at the end of a run or at a terminus.

It has been stated that the American engineers who have been considering the question of equipping the Metro-

Name.	Length of line.	Weight of train.	Distance between stations.	Average and max. speed.	Remarks.
American—					
Manhattan Elevated ...	110 miles of single track.	150 tons.	·35 mile.	—	Car-miles operated in one year, 44,500,000. Passengers carried per year, 190,045,741.
Brooklyn Elevated ...	68 miles of single track.	150 tons.	·33 mile.	14 m.p.h. 26 m.p.h.	Car-miles operated in one year, 14,314,986. Passengers carried in one year, 62,587,361.
Metropolitan Elevated, Chicago	8·25 miles of route.	68 tons.	·306 mile.	—	26,141,858 passengers carried in 10 months.
South Side Elevated ...	10·75 miles of route.	80 tons.	·322 mile.	—	During year 1900, 24,990,878 passengers carried.
Boston Elevated ...	350 miles of single track.	90 tons.	·473 mile.	—	Passengers carried in one year, 201,124,710.
Nantasket Beach (N.Y.N.H. & H.)	18·33 miles single track.	3—5 cars per train, each car weighing 30 tons.	—	24 m.p.h. 44 m.p.h.	Average watts per ton-mile, 76. Average acceleration, 4·4 ft. per sec. per sec. Motor equipment consists of four motors of 175 H.P. each.
Continental—					
Paris—Orleans Extension	8·8 miles of single track.	Loco., 45 tons. Train, 206 tons.	—	—	150 trains per day. Motor equipment, four 125-H.P. motors. Average watts per ton-mile, 47.
Paris Metropolitan ...	8·7 miles of single track.	Motor-car, 16 tons. Trailer, 8 tons. Train, 60 tons.	·37 mile.	25 m.p.h. 31 m.p.h.	Max. passengers per day, 190,000; 15,89?,528 passengers carried from Oct.—Dec., 1900. Train consumes 72·5 watts per ton-mile. Max. starting current for one train = 220 amperes.
Burgdorf—Thun, three-phase	25 miles.	Motor-car, 32 tons. Trailer, 14 tons.	·2 mile.	22 m.p.h. average.	14 trains in each direction per day. Motor equipment, four motors of 60 H.P. each, geared.
Milan — Gallarate — Porto Ceresio, 3rd rail	245 miles.	73 tons.	24·5 miles.	49 m.p.h. average.	
Berlin Elevated and underground.	7 miles.	84 tons.	—	12·4 m.p.h. 20 m.p.h.	Five minutes' service.
Berlin to Wannsee ...	7·5 miles.	Motor-car, 32 tons. Train empty, 210.	1·5 mile.	34 m.p.h. max.	Two motor-cars per train of 10 cars.
United Kingdom—					
Central London ...	6 miles of double track.	Train, 140 tons. Geared loco., 32 tons Gearless, 43 tons.	·49 mile.	14½ m.p.h. schedule.	Seven cars per train hauled by one loco.—each car weighs 35 tons. 1,000,000 passengers carried per week. Average watts per ton-mile = 46. Average acceleration, 12 in. per sec. per sec.
Liverpool Overhead ...	6½ miles of double track.	Trains, 51½ and 38 tons each.	·38 mile.	26 m.p.h. schedule.	5,000,000 passengers carried per month.
City & South London ...	6½ miles of double track.	Train, 21 tons.	·4 mile.	15 m.p.h. schedule.	Average watts per ton-mile = 38.
Waterloo & City ...	3 miles of single track.	Train, 105 tons. Car, 26 tons.	—	18 m.p.h. schedule.	Three-car train hauled by loco.

politan District Railways have approached the problem from the wrong end, and that it should be considered from the point of view of what system would in the near future be used on our main lines for long distances, so as to enable through trains to be run. As we have tried to show, the time for running long-distance lines electrically, at any rate as far as this country is concerned, has not yet come; furthermore, there is no practical experience available to show how such a line should be equipped. The reverse is the case as far as handling heavy suburban traffic is concerned, and the time is fast approaching when all our important railway companies must most seriously consider whether it will not pay them to run their suburban traffic by means of electricity. The London County Council, with its proposed electric tramways, will soon greatly decrease railway receipts, unless a faster and more comfortable service is installed. It would, therefore, appear that the only sensible course to pursue would be to instal that system which has proved itself satisfactory, which is commercially economical, comparatively safe and no longer experimental. New systems should have a chance, provided the promoters have sufficient faith in them to instal an experiment on a commercial scale, so that really practical data may become available. This has been done by the German firms who subscribed to the syndicate which is now carrying on trials between Berlin and Zossen. No excuse, however, exists for spending shareholders' money in putting down plant which is still in its experimental stage, with the expectation that it will be commercially successful.

Let us briefly examine the problem of electrifying our main line railways, as regards their suburban traffic, bearing in mind the future possibilities should long-distance trains run electrically.

The conductors cannot be overhead as long as a combined steam and electric service is run over the same lines, because the deposits formed on the wires would cause serious sparking. If the conductors are on the ground, they must be protected so as not to be easily accessible to the employés; at the same time the pressure used should be such as not to be fatal should anyone come in momentary contact with them. If possible, it would be advisable to have both conductor rails entirely insulated. This may not always be convenient, especially when a three-wire self-balancing system is under consideration, with the rails acting as third conductor.

To eliminate the danger of high tension wires over the trains the Germans, in their experimental line, put the three trolley wires one above the other at the side of the track; this would not be feasible in the problem we are considering.

The ideal method of operating an electrical suburban service would be to have a light structure on which the electric train would run, elevated above the existing lines. At junctions, the lines would be run over or under each other in such a way as to totally avoid crossings on the level; at the termini, loops might be provided. This would enable the trains to follow each other continuously, and the danger of collisions could be greatly reduced. Should this double storey line not be possible, which is the case as long as steam trains are run under it, separate lines should be provided for the electrically-operated trains, so as to reduce the delays to a minimum.

There are several lines on which the main line trains run punctually until the suburbs are reached, after which there are constant delays. In such cases it would be quite possible to hitch on an electric locomotive at the junction to haul the train into the terminus. This method would reduce to a minimum the smoke, steam and noise usual on existing suburban lines and in the stations.

Where any such transformation is carried out, false economies are fatal, for though the fact is not apparent at first sight, a large original outlay often means a great saving in the long run. Any considerations as to the use of existing rolling stock should always be subordinated to the question whether it is really the best suited for the purpose.

The ability of electricity to work heavy suburban traffic does not require to be proved by experiment, but should the latter be deemed advisable, it should be carried out as a part of the whole scheme, which, from the commencement, should be worked out in its entirety, with a view to all future possibilities.

All said and done, the whole root of the question is entirely a financial one, and the fullest measure of success can never be expected, unless the preliminary studies of the

system are carried out on a sound *commercial engineering* basis. The engineer who reports on, and carries out, a scheme of this magnitude, should be a first-class business man, as well as a sound and experienced engineer. He can only hope to be really successful if he combines in himself these two qualities. The four chief items which must be most carefully weighed and compared, are capital expenditure, maintenance, working expenses, and receipts. In this comparison the possibilities as well as probabilities of the future should never be left out.

Engineering is cosmopolitan, and the engineer, while maintaining his individuality, should never scorn to learn from results obtained by others. Neither practice nor theory alone suffices; both should be used in the proper proportions in each case. It has been customary in the past to talk of continuous current and alternating current engineers. The engineers of to-day must be well acquainted with both, and not prejudiced in favour of either; existing conditions alone can decide which system should be employed, or whether what has been called the mixed system is not to be preferred.

With the equipment of the Metropolitan District and its branches a new era of electric traction will commence in this country, and it cannot be doubted but that the electrification of most of the suburban lines will very shortly follow. Such an undertaking should not be entered into lightly or without most careful calculation of the probable results of conversion and the best way of carrying it out.

To sum up, electric traction on main line railways, as far as long-distance runs are concerned, is still a thing of the future, and it is highly experimental.

Electric traction on congested main line railways, as far as local and suburban traffic is concerned, has been proved to be advantageous from all points of view; its adoption in the near future is a certainty.

Electrification should not take place piecemeal, nor are experimental lines necessary to show what results may be expected. Should such experiments be deemed advisable they should be carried out as part of a complete scheme.

No theoretical reasons or laboratory experiments warrant the installation, at the shareholders' expense, of any untried system, no matter how promising, unless they are prepared to spend a great deal of time and money on pure experiment on a large commercial scale.

Sound commercial, as well as engineering, knowledge is required in the engineer in charge of laying out a traction scheme of such magnitude as that involved in the transformation of our railways. Under these conditions it is very advisable to carefully consider and weigh the results obtained by others in the same field before coming to any conclusion.

ECONOMY IN PLANT FOR TRACTION STATIONS.

By an Engineer.

The machinery and plant in a power station must be provided in widely different proportions according to the system employed, and the economy of any design can only be ascertained by finding the interest and depreciation charges and the working expenses, and ascertaining what arrangement gives the best result.

A convenient method of showing the process of design will be as per the annexed chart (p. 962). On the left is shown one system, on the right another system. This chart may be extended for details and elaborated, but the present outline will make plain the idea.

Starting with a proposal to run a service of 27 cars, it is first necessary to know how much current to supply and what will be the ratio of minimum to maximum load. The latter, the load factor, will be 33 per cent. If the cars are ordinary single truck cars they will each demand an average of 6 units per hour, or a total of 162 KW. Assuming a battery (on the left) to give 80 per cent. return, this battery must have a capacity of 324 KW. for one hour discharge. This is the largest battery that need be assumed, because in this calculation no allowance is made for the toning-down effect upon the engine load of the fly-wheel. This, however, it is not desirable to take into account. Now we do not know what is the mean output of the battery, but we know that approximately it is discharging half the time at rates from 0 to 324, or at a mean of 162 for half the time, that is to say, its mean output is 81 KW. It has therefore a mean input of 101 KW. The extra 20 KW. must be originally generated by the engine. This 20 KW. is what we have to pay for the economy we hope to secure by using the battery. It increases the size of our set for constant load from 162 to 182 KW. We have, therefore, steam and electrical plant, including the 182 KW. set, 324 KW. accumulator, and a booster, say, of 30 KW., to develop 10 per cent. of the maximum battery pressure for assistance in charging and discharging the cells at periods of light and heavy load respectively.

The above ratio of battery output is taken in order to avoid over-stating the case. It assumes that the mean fluctuation diagram consists of a series of narrow rectangles based on the mean load line. As a fact, of course, the diagram consists of a series of narrow triangles based on the mean load line, and of varying heights. As the centre of gravity of a triangle is at one-third its height, the mean fluctuation will tend to approach rather to one-third than one-half of the average height of the triangles, or to one-sixth of the maximum fluctuation, in place of the one-fourth assumed. The exact proportion can only be found by carefully measuring the diagram or metering the current input to the battery, if this is present. The point is not of very special importance, because it will not affect the size of the battery, for this must, in any case, be big enough safely to discharge current for the maximum fluctuation. It only affects the question of the amount of battery loss, which will be less according as the mean fluctuation is less. The point is emphasised merely because there is a tendency to value the efficiency loss of a battery as though this dealt with more current than it actually does. A battery that really dealt with all the output would lose probably a minimum of 20 per cent. of its input, but as a traction battery may only be dealing with a mean of considerably less than the whole current, the loss is proportionately less when spread over the whole output. This point of view should be considered when settling upon the running of the system entirely from the battery. Probably this will be found to pay only during the period of shedding and unshedding, so as to cut down the duration of the two engine room shifts to a reasonable number of hours.

As the engine is to work at a steady load, we may allow it 2½ lbs. per I.H.P.-hour upon 182 KW., making a total of 607 lbs. of coal per hour. This can be burned on a grate surface of 29 sq. ft.; one Lancashire boiler of 7 ft. diameter will contain this area, and there will be another similar boiler as spare. The 7-ft. Lancashire boiler has an undesirably small furnace diameter, and it remains for the designer to select either this boiler, a water-tube boiler, or, perhaps, a Cornish boiler of 6 ft. diameter, with furnaces at least 3 in. larger than the 7-ft. double flue boiler. There would then be two 6-ft. Cornish boilers at work, and one at rest as spare, as against two Lancashire boilers. An economiser of 96 pipes would complete the steam raising plant.

On the other side the load factor of 33 per cent. points to a maximum load of 486 KW., to do which, we may assume a generating set of 350-KW. capacity, or, say, three running sets of 120 KW. and one set spare, as against, on the other design, two sets running of 80 KW. each, and one set of 80 KW. spare.

In place of coal at 2½ lbs. per KW.-hour on 182 KW., we must now allow 6½ lbs. on 162 KW., making a total of 1,404 lbs. per hour, which, at the same rate of combustion as before, gives a grate area of 67 ft. This demands two 7-ft. boilers working and one as spare of Lancashire type. We might, of course, employ five Cornish boilers of a total of 85 sq. ft. of grate surface, instead of the three Lancashire boilers with a total of 100 sq. ft., just as we might in the first design have employed three Cornish boilers of about 45 sq. ft. of grate surface in place of the two Lancashire boilers with 58 ft. area of grate. Finally, we need 240 economiser pipes. Tabulating the plant we now find:—

	No. 1 design.	No. 2 design.
Generator sets	182 KW.	350 KW.
Battery	324 KW.	——
Booster.	30 KW.	——
Cornish boilers	3	5
Economiser...	96 pipes	240 pipes
Condensing plant	182 KW.	400 KW.
Feed pumps	607 gallons	1,400 gallons
Buildings	£x	£$\frac{3}{2}x$
Draught apparatus... ...	£y	£2y

Having arrived thus far, we may now obtain approximate prices for the plant and for the buildings, having prepared an approximate ground plan of what it is necessary to provide. In the first design the only increase in building will be for the battery, for which a cheap building will suffice. For the generator sets the engine room area will be from half to two-thirds the area necessary for the second design. The boiler house will be about two-thirds the area at most, and the economiser shed about one-half, while with half the coal bunker capacity a greater proportion of coal can be accommodated.

These are the capital expenses on which interest and depreciation must be apportioned and added to working costs. In favour of the first design it is certain that there may be a reduction in the engine room staff; also one fireman will serve, where two would be harder worked on No. 2 design. Coal itself is reduced to less than half, and so, of course, is any charge for water, oil, and waste.

Against the loss of 20 KW. incurred by the use of a battery, we may set the loss of steady vacuum which is sure to occur unless the condensing plant is fully up to the dimensions necessary for the maximum power of 486 KW. Condensing plant is only set down as for 400 KW., and this is not excessive with which to debit No. 2 design, because, after all, the mean steam is $2\frac{1}{3}$ times that of No. 1 design, and there will be a very heavy flush of steam into the condenser at periods of heavy load. The best arrangement for condensing plant would be one that provided ample cooling surface and a variable-speed air pump, if this could be arranged, for driving off the main circuit on the generator side of the main cut-out.

Apart from the chimney or other draught apparatus and exclusive of buildings, the first estimate will probably be found to effect a monetary saving of 25 per cent. capital outlay, while the saving in coal alone will amount to over £1,000 annually at 10s. per ton. Oil and stores generally will be reduced proportionately with the dimensions of the plant.

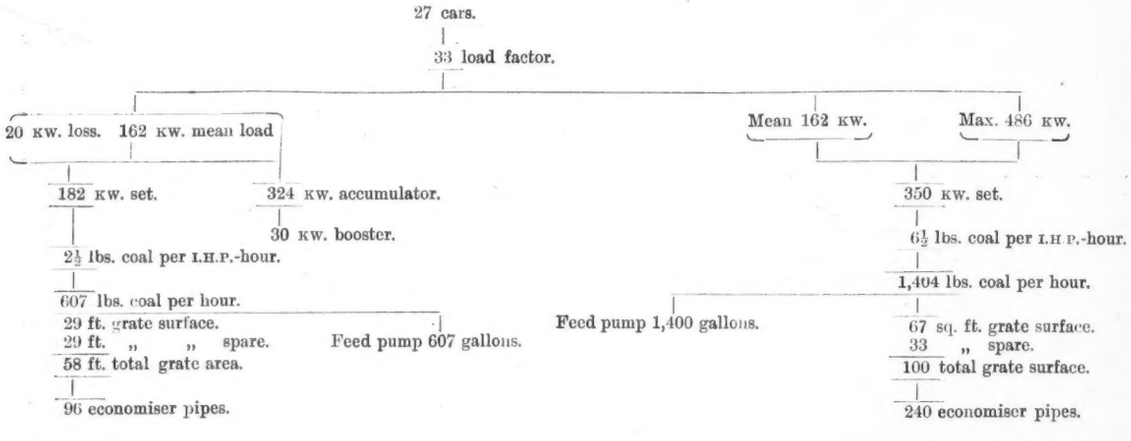
There is an ample margin for the battery to be less efficient than is assumed above and for heavy depreciation to be allowed upon it.

One of the heavy items of cost in any steam plant is the chimney. It is costly to build, in the first place, and it is fixed to the freehold and of no movable value. It is necessary to build it too big, to allow for future extensions, and these if not carried out leave the chimney standing as an example of inability to foresee the future, or if the engineer has exercised due caution the station probably soon outgrows the chimney and a second one is wanted.

It is not easy always to arrange No. 1 chimney so that No. 2 will work in with it to a harmonious design, and often the first chimney exercises for ever after a bad effect on all extension work. A fan-draught plant, on the other hand, is smaller in first cost, can be sold to make room for enlarged plant, and can be moved with its short chimney to any convenient location. It is productive of a better draught than a chimney can give, and with less power to drive it, for by means of a fan the economiser surface can be increased, and waste heat can be saved that is otherwise uneconomically employed to actuate the chimney draught. Moreover, the fan draught enables cheaper fuel to be burned on a less grate area, with better combustion and less excess of air. The fan-induced draught is, therefore, an economy that ought to be carefully considered.

Condensing is always an economy. It is doubly so where steam plant must be designed on the lines of design No. 2 above, because in case of such excessive engine power the relative addition of forward pressure is greater than it is in a properly loaded engine. It ought to be added to the credit of No. 1 design, that the engine and generator, being of barely half the power of No. 2 design, will have only half the frictional loss. Taking the frictional loss of plant at 16 per cent. overall from I.H.P. to main ammeter, that of No. 2 design represents 56 KW. as against 26 KW. in No. 1 set. There is a difference here of 30 KW. to be set against the 20 KW. of battery loss, and in an actual design these points must all be considered. It appears, in fact, that in this particular case the frictional loss in the generator plant may quite balance the battery losses, even at an allowance of only 70 per cent. of battery efficiency. In an actual design, of course, one would first find the KW. required at the switchboard, allowing for inefficiency of battery, and then translate this into I.H.P. in the cylinder at 84 per cent. of overall efficiency.

In the skeleton designs nothing is allowed on either side for this factor, but had it been taken into account, it would simply have shown still better for the No. 1 design in coal, boiler plant, pumps, &c. This item of frictional losses of steam and generator plant is too usually omitted when ordering engines to be "big enough" for traction stations, and of necessity too big in any case when not provided with accumulators; even when without accumulators, an engine is very frequently too big for the generator attached to it, as is proved from the fact that it will generally be capable of turning the generator at such an output as to cause damage to it.



SHALLOW UNDERGROUND TRAMWAYS.

By C. H. WORDINGHAM, M.Inst.C.E.

The joint report of Messrs. Baker and Rider, presented to the London County Council, on shallow underground tramways is full of interest to electrical engineers, and contains as well matter of considerable moment to the general public.

The authors of the report, accompanied by Mr. J. Allen Baker, vice-chairman of the Highways Committee of the Council, visited Boston and New York with a view to examining on the spot the shallow subways which have been devised for accommodating the trams in certain parts of those

cities. At Boston they found the system at work, so that they could judge of its actual operation and of its effect upon the traffic; while in New York they had the advantage of seeing the details of the work during construction and of examining the means adopted to deal with the ordinary traffic while the roads were disturbed. The information they were enabled to gain is thus very complete, and the clear description given, together with the typical photographs reproduced, make the report a valuable one.

It may be well to define precisely what is meant by the expression "shallow underground tramways." They are, in fact, ordinary tramways with ordinary tramcars running, as it were, on a basement floor of the street; that is to say, a portion of the street is excavated and then roofed over, the roof being of sufficient strength to carry the ordinary traffic. These subways, therefore, differ from tunnels such as those in which the District Railway runs, and from the deep level tubes of which the City and South London Railway was the earliest example, while the rolling stock differs from that of railways in that it consists of tramcars similar to those used in surface work, the cars actually running on the usual lines above ground for the greater part of their course.

The first portion of the report is historical, and describes the genesis of the undertaking in Boston. It is only of interest as showing the state of the streets in that city, which led to sweeping measures being proposed to relieve the congestion of traffic. It is stated that the rate of progress was often not in excess of two miles per hour.

It does not seem to have occurred to the writers that such a state of things was in all probability largely due to permitting trams to run in the principal thoroughfares, but, *pace* the tramway enthusiast, there can be no doubt that tramcars are a considerable obstruction in busy streets, in whatever manner they may be propelled. No better object lesson could be had than that furnished by Manchester, in which Market Street, the principal business thoroughfare, is often practically completely blocked on account of the cars, which, at certain hours of the day, form an almost continuous procession from end to end. The difficulty is due to the inflexibility of the tramways, and the London County Council would do well to pause before they seek to introduce tramlines in some of the London main streets, and to consider whether for short distances the present system of numerous omnibuses, that can so well thread their way through other traffic, does not really meet the public convenience better than any tramcars could, especially if they are motor-driven.

Before leaving the historical account, one point may be noted which speaks well for the long-suffering patience of the Commissioners who were charged with the preparation of the scheme for relieving the congestion of traffic in Boston. We are told that they gave a public hearing to all persons desiring to aid them by advice or suggestion! Those whose fate it has been to have to listen to the gratis advice of enthusiastic cranks and the panaceas of the man in the street will admire their self-sacrifice, whatever they may think of their wisdom.

The Boston Commissioners arrived at conclusions which were drastic in the extreme, being no less than a construction of new streets, the reorganisation of the existing tramways, including the formation of subways in certain streets for cars to run in, and the erection of two complete lines of elevated railways. All these remedies have been applied, with the exception of the construction of the new streets, and presumably it has been found that the other expedients have rendered this unnecessary.

Into the details of the construction of the subways, both in Boston and New York, it is unnecessary to enter, except to note that the authors greatly prefer a rectangular subway having steel ribs filled in with concrete to form the sides and roof, and resting on a concrete bottom. This system has been adopted almost entirely for New York, whereas in Boston single and double masonry tunnels are also employed.

In Boston it was a stipulation that the streets should be left open for traffic from 8 a.m. to 6 p.m. each day, and it was stated that this condition was fully adhered to. In many streets in London, however, it would be necessary to leave them open at least until midnight.

Turning to the conclusions of the report, we find that in them the chief general interest centres. These conclusions are supplemented by an addendum by Mr. J. Allen Baker, in which he confirms and emphasises them, and strongly recommends immediate action in the matter by the County Council.

The writers are evidently very much impressed with the advantages of the system which they have examined, and the insistence with which they contrast it with that of the deep-level tubes is somewhat remarkable, and, it would seem, uncalled for. There is a considerable difference between the purposes best served by the two systems, and in any comprehensive scheme of transit each may usefully find a place. The essential feature of the shallow subways is that they provide a means of affording nearly all the advantages of a quick service of tramcars in crowded streets—that is to say, they run at a moderate average speed with very frequent stopping places, whereas the deep-level tubes afford rapid transit between extreme points with comparatively few stops on the way.

There appears to be a somewhat widespread tendency to look upon tramways as affording an expeditious means of communication over the whole of a large area, merely because the tramlines are continuous. Thus, a short time ago, one heard a good deal of the advantages accruing from covering the whole of South Lancashire with a network of tramways, much being made of the point that it would be possible to travel by them from Manchester to Liverpool; but what person in his senses would ever dream of doing this? The real boon of such a system lies in the facilities it affords for communication between any two points on the system a moderate distance from one another. For this reason an interruption in the continuity of the lines, such as exists in London between the Northern and Southern portions, is not nearly so serious a matter as is implied in the report, and only affects a small local section. The convenience of the public would be quite well served by deep level tubes with a reasonably frequent train service communicating between extreme Northern and Southern, and extreme Eastern and Western, points, with certain intermediate stations, supplemented by a general system of tramways giving travelling facilities between the intermediate points on the various tubes.

As to the advantages of running the trams in subways instead of on the surface in crowded thoroughfares, there can be little doubt that the report is wholly right, and that this method, if it be feasible to carry it out, does afford an admirable means of solving the problem. It is surprising that in the report no reference is made—and in the addendum only the briefest—to the Metropolitan Railway in Paris. Perhaps this was too near home to be carefully studied, but anyone who has had experience of the immense boon afforded by the construction of this railway cannot fail to recognise the merits of the system. It is quite refreshing in summer weather to travel by the subway, there being always a constant fresh breeze of cool air issuing from the stations. The whole route is well lighted as in Boston, and the travelling is most agreeable. The construction of the subway is practically identical with that described, and experience of its use confirms the observations of the writers of the report as to freedom from noise, vibration and other drawbacks.

While agreeing as to the advantages and desirability of constructing subways of the kind described, one cannot but pause when one considers the enormous difference in the difficulty of constructing the subways in London compared with Boston, New York, or Paris. These difficulties are to some extent recognised by the writers, but their full magnitude hardly seems to be realised. A large part of the Boston work was apparently carried out beneath public gardens, while in New York the streets are of considerable width. In Paris the streets are wide, and a good deal of the work was done beneath the Champs Elysées. Contrast the difficulties of carrying out the work under any one of London's busy streets. Take Wellington Street alone, which is one of those actually proposed for an experiment. It is to be doubted whether there is a busier corner in the world than that at which Wellington Street joins the Strand. Few things are impossible to the engineer with unlimited capital behind him, but he must be a brave man indeed who is not appalled at the magnitude of the task of constructing a cut and cover tunnel beneath such traffic, especially when he has

a mental vision of the pipes and other obstructions concealed by the pavement. If subways are to be constructed at all, one would think that the wisest plan would be to choose back streets and not main thoroughfares for the routes; streets which, though too narrow or busy to admit of surface tramways, might yet be closed without undue inconvenience for a time while the work was being carried out, and in which the pipe and cellar obstructions would be a minimum.

Another difficulty of which little has been made, but which would be a very real one in the narrow streets of London, is the provision of means of ingress and exit for the subways; few of the streets are wide enough to admit of these being placed in their middle, and fewer still have pathways that would bear being narrowed sufficiently to allow the staircases to come to the surface. It would be almost imperative to acquire property to enable the stations to be placed behind the building line, and this would add substantially to the cost. The difficulty of finding suitable places for the inclines where the surface and subway portions meet would be even greater, and, in many cases, practically insuperable, unless the roads were widened at enormous expense. The line proposed as an experiment begs this question as far as the Embankment end is concerned, since that thoroughfare is very much below the level of the Strand.

The writers of the report express considerable astonishment at the fact that no provision has been made either at Boston or New York for the accommodation of pipes in the tram subways, and they somewhat airily take for granted that they can, without much difficulty, make such provision in the London subways. The whole question of subways for pipes is one which appears to have received very little careful attention. It seems usually to be assumed that they afford a complete remedy for the trouble arising from the disturbance of the streets, and that it is only a question of cost whether they shall be constructed or not.

The subway, however, in point of fact, is really not a solution of the problem. No doubt it would be thoroughly effectual so far as trunk gas mains, electric feeders, and so forth are concerned; these merely have to run through from one point to another, and can be well accommodated in a tunnel, though there would always remain the danger of serious explosions in the event of gas escapes. The chief difficulties, however, do not arise from these trunk lines; electric feeders, for example, can readily be laid on a drawing-in system, and an adequate number of spare ways can be provided at the initial opening of the ground, while additional trunk gas and water mains are only wanted at very long intervals. It is the distributing mains, whether of electrical energy, of gas, or of water, that present the real difficulty. How is a subway to enable attachments to each system of mains to be made from every house on both sides of the street? Either the whole space between the house foundations on both sides must be excavated, and one huge tunnel be formed, or there must be two subways, one on each side of the street; or lastly, there might be a main subway in the middle of the street, and subsidiary subways on each side.

In any case, it is difficult to see how the tramways subway would be of use except for trunk mains. It could not well be run under either pathway, and if central, it would not save any appreciable amount of the cost of the subsidiary side subways.

Apart from these difficulties, there would be considerable drawbacks to utilising the tram subway for the purpose proposed. In the first place, unless it were considerably enlarged, it would be exceedingly dangerous and inconvenient for any work to be done except when the traffic was suspended, and an all-night service, whether for passengers or goods, must be looked forward to in the near future. Further than this, there is almost certain to be some escape of gas and water, and the effect on the wholesomeness of the tunnels would be serious. That these difficulties are very real seems borne out by the fact that the American Commissioners considered the matter and decided not to utilise the subways for the purpose.

Lastly, there is a further point in this connection which is entirely ignored by the writers, *i.e.*, that the tramway subways will run in comparatively few streets, while they can hardly be taken through the principal thoroughfares, which are the very ones most affected when the ground has to be opened to get at the mains.

The authors conclude their report with an approximate estimate of the cost of constructing the subways that they recommend. They anticipate that the work could be done in London for £350,000 per mile, but they expressly point out that this figure does not include any allowance for the purchase of vaults, cellars or vested interests of other kinds, nor for the addition of pipe galleries to the subway, and the transfer of pipes to them. It is, however, the obstructions near the surface that form the crux of the whole problem, and their existence has been chiefly responsible for resort being had to the deep level tubes. One cannot but think that in London these omitted items would amount to a very heavy sum, comparable, indeed, with the figure estimated for the construction, and that, apart from the actual cost in money, the difficulties encountered in arranging with the various parties interested might prove well-nigh insuperable.

In conclusion, one would be glad to see the experiment of a shallow subway tram route tried in some suitable part of the metropolis, but one cannot view, without a pang, the prospect of our only Boulevard, and that, perhaps, the finest in Europe, being disfigured by the ugly, if useful, tramcar. Meanwhile, it is to be hoped that no check will be given to the private enterprise whereby North and South, East and West, of the metropolis may be effectually linked together by the projected tubes, which will enable the inhabitants of those quarters to visit one another without undertaking a journey infinitely more tedious, as it is at present, than, say, that from London to Birmingham. There is room for the County Council's tramways, and for the public companies' tubes, if each authority will only recognise its proper sphere.

CORRESPONDENCE.

Tramway Specification.

It may interest you to have your attention called to the following figures, taken from curves which form part of the specification just published for Reading tramways.

The curves read 500 volts, 25-H.P. motor at 15 amps., 160 lbs. tractive effort, 16·6 miles per hour, 72½ per cent. efficiency.

At 20 amps.	...	...	300 lbs.	12·7 m.p.h.	79 % η
„ 23 „	...	...	400 „	11 „	80½ % η
„ 25 „	...	...	460 „	10·6 „	81 % η

At higher currents they are more consistent.

Roughly checking the efficiencies, I find—

From curve.		From $\frac{\text{lbs. pull} \times \text{ft. per sec.}}{\text{amps.} \times \text{volts} \times 550 \times \eta}$
Amps.	% η	% η
15	72½	70
20	79	76
23	80½	76·1
25	81	77½

Does Reading require the efficiencies specified, or the speed and pull? They cannot have all.

I do think consulting engineers' specifications should show consistency in matters of comparatively elementary arithmetic.

R. R. R.

London Subway Tramways.

Now that the London County Council has begun to think of shallow underground tramways, it may not be out of place to recall that in 1889 a Bill was promoted in Parliament to build such a line from St. James's Street, Piccadilly, to Holborn Circus, at an estimated cost of about £600,000 per mile, and to be worked electrically.

The intention was to place the rails about 12 ft. only below street level on a 2 ft. bed of concrete, and to make the roof of the subway the road surface by a system of

girders. All pipes were provided for in subways alongside, the pipes bending behind the stairways. Access to the line was to be down a few steps only from the street surface. The Bill was opposed strongly and lost, among the opposing witnesses being Mr. Charles Harrison, of the London County Council.

Needless to say, Mr. James Staats Forbes opposed. He described as "bunkum" the complaints about the foul atmosphere of the Underground. Perhaps he has learned better since. Sir Frederick Bramwell and the late Mr. Greathead also opposed. Shopkeepers opposed because it would carry passengers past their selfish doors, and now they have a deep tube that does the same thing, only more so.

Mr. Crompton estimated the average I.H.P. as about 1,000, and provided 2,400 I.H.P. of ordinary rating, which means a possible 3,400 I.H.P.; Mr. Crompton was not far wrong, and he at least need not feel ashamed to-day of the evidence and estimate he made 12 years ago. Reading old engineering evidence is not a bad way of arriving at a present day opinion of a man's judgment in making estimates on problems without much guiding precedent. Is it not a pity the line did not go through? It would have saved its cost long ago in street uptearing, and there would have been many more miles by this.

One of Them.

Telephone Tariffs.

Having had occasion to study telephone tariffs, I take great interest in the subject now occupying so much attention in your columns.

The statement of Mr. Provand in the *Times* of November 30th that Glasgow is earning a profit on £5 5s. subscriptions, leads us of the *métier* to seek further information, for no other large city has been able to maintain so low a rate.

£5 5s., less 10 per cent. Post Office royalty, leaves £4 14s. 6d. net. I take the ultimate capital cost per subscriber, as given by Mr. Provand, at £16, but I think no telephone manager will accept 3½ per cent. per annum as a sufficient depreciation. My experience is that if the service is to be kept up to the mark the instruments and switchboards must be replaced about every eight years, which means, say, 12 per cent. depreciation. Cables and conduits last longer, but repairs and replacements are always necessary, and the very lowest admissible depreciation I put at 5 per cent. Taking, roughly, instruments at one-third, and other plant at two-thirds of the capital outlay, we have 7⅓ per cent. average depreciation, or, with 3·2 per cent. interest, a charge of 10·5 per cent. on the capital invested in plant.

Now, 10·5 per cent. on £16 makes £1 13s. 10d. fixed annual charge per subscriber. Of the £4 14s. 6d. we have left, therefore, for all operating expenses £3s. 0s. 8d. This sum will cover only 243 of those 3d. communications which Glasgow kindly pays for when a subscriber speaks to some one on the National Company's exchange at Paisley or elsewhere. Lucky subscriber and lucky company, but how about the municipal telephone revenue? The subscriber who thus communicates 20 times a month uses up his £3 0s. 8d., leaving nothing for operating or other expenses.

In a busy town like Glasgow, there will be subscribers who call 20, 50, 80, or even 100 times a day. A line is well loaded with 80 outgoing calls daily, so let us take that as a maximum. The average switchboard allows about 1,200 calls to be handled at an operator's place daily. Some systems do more, some less, but let us take 1,200 with two operators per place to cover day and night service—a low allowance. I do not know the wages of Glasgow operators, but assume £3 10s. a month—they get more in France and Switzerland.

Two operators at £3 10s. a month cost £84 a year. But of 80-call subscribers you can put only 15 to an operator's place, so that each such subscriber costs £5 12s. a year for operators' wages alone, or nearly double the sum available to cover *all* expenses! A little more arithmetic shows that every subscriber who calls 47 times daily uses up his subscription price in operators' wages alone. Then we have, also, management, technical staff, batteries, repairs, rent, lighting, heating, and all the multifarious expenses of a large business enterprise still to come. Of course, the subscribers do not all talk 80 times daily, but that only illustrates the fact that on any "flat rate" system the small subscriber pays too much to make up for the big one who pays too little.

But this is not all. The subscriber who calls 20, 40, or 80 times daily, costs more than £16 in plant. He may cost £25 or £50, for he takes more switchboard room, and the depreciation on that head is 12 per cent., making with interest 15 per cent. The £5 subscriber will thus cost about £7 per annum for interest and depreciation, say 1½ times his subscription fee.

These considerations and the demand for justice to the small user are gradually forcing public and private administrations to give up the "flat rate" for the "message rate."

The principle is recognised in the Post Office tariff announced for London, which, however, is open to criticism. The minimum for the small subscriber is low, and the penny charge for a conversation cannot be grumbled at; but I think the "flat rate" of £17, when combined with the very low "message rate," will be recognised by most experts, including the Post Office officials, as not too high but far too low. Many Swiss subscribers pay more (up to £80) on the "message rate" system, yet the Swiss Administration has a yearly increasing deficit, the base price of 40 f. being below cost.

Let us not blind ourselves to facts and figures, but remember that the public interest calls for a fair price to be paid for public service, especially when rendered by Government.

What the public demands is not so much cheapness as good service. Most of the complaints at the Glasgow Telephone Inquiry were of bad service, the witnesses declaring one after another their willingness to pay the price if they only got the service. A first-class telephone service in a great town can never be cheap.

The best example known to me of a scientific tariff is that proposed for the Australian Commonwealth by a committee of experts, presided over by the respected Postmaster-General of South Australia.

For large exchanges this tariff starts with £5 per annum, including 300 calls, with 1d. per additional call up to 1,000. As the number of calls increases, the rate decreases to ¼d. At what the committee apparently consider the practical maximum of 20,300 calls per annum (68 daily at 300 days per annum) the subscriber will pay £33 2s. 6d. This is for Melbourne, Sydney, Adelaide, and Brisbane, as compared with £17 for London, with its 634 square miles of territory. We in the service know London to be the most difficult place in the world to telephone, and, after New York, probably the most expensive. Although without exact data on which to base the opinion, I should incline to put the proper "flat rate" for unlimited calls in London at nearer £50 than £17.

It may be the happy-go-lucky municipal financing which gives unlimited service in a big town at rates like £5 5s. will bring the taxpayer some very valuable, if costly, experience; but the ground thus traversed as virgin soil has already been well laboured, and through dearly bought experience, telephone managers and engineers have arrived at some very definite results, which are not secrets, but common property. Competition in telephony is an anachronism, and the rates proposed for London err, if at all, in the direction of being too low rather than too high.

I shall probably never have the privilege of paying taxes in Glasgow; I shall seldom use the telephone in London, and it may seem presumptuous for an outsider to interfere in the discussion of a domestic question. But we are all, throughout the world, interested in the subject, which is of universal interest, for the telephone is one of the essential means of communication in industrial, commercial and social life, and it seems to me the duty of those engaged in telephony to support your example in making known the truth, to controvert error, and to correct mistaken impressions in the minds of the public. That is my apology for this letter.

G. de la Touanne,
Telegraph Engineer,
Foreign Member Inst. of Electrical Engineers.

Paris, *December 5th*, 1901.

BUSINESS NOTES.

Electrical Wares Exported.

WEEK ENDING DEC. 14TH, 1900.		WEEK ENDING DEC. 10TH, 1901	
Alexandria	Value £1,342	Adelaide	Value £28
Amsterdam	85	Amsterdam	97
Antwerp	242	Auckland	£0
Bangkok	33	Batoum	200
Beira. Teleg. mat.	311	Bombay	189
Bombay	57	Boulogne	36
Buenos Ayres	59	Buenos Ayres. Teleg. cable ..	476
Calcutta	262	Calcutta	992
Cape Town	268	,, Teleg. wire	337
,, Teleg. apparatus ..	82	Christchurch	40
Christchurch	56	Colombo	106
Colombo	43	Copenhagen	31
Copenhagen. Teleg. wire ..	76	,, Teleg. cable ..	186
Durban	58	Dardanelles. Teleg. cable ..	115
,, Teleph. mat.	97	Durban	1,031
Genoa. Teleg. mat.	80	Fremantle	140
Gibraltar	9	Gothenburg	28
Halifax	12	,, Teleg. wire	22
Hamburg. Teleg. mat.	600	Hobart	25
Hiogo	149	Hong Kong	120
,, Teleg. mat.	66	Melbourne	633
Hobart	22	St. Petersburg. Teleg. mat. ..	2,000
Hong Kong	150	Santos	571
,, Teleph. mat. ..	115	Stockholm	90
Kure	200	Sydney	750
Leghorn. Teleg. mat.	81	Wellington	79
Lisbon	1,100	,, Aerial cable ..	1,047
Malta	21	,, Submarine cable	493
,, Teleg. mat.	55		
Melbourne	532		
Nagasaki	103		
Ostend	447		
Penang. Teleg. mat.	212		
Port Chalmers	65		
Rangoon	60		
Singapore	83		
Stockholm. Teleg. mat. ..	79		
Sydney	555		
Wellington	49		
,, Teleph. and matri.	900		
Total ..	£8,766	Total ..	£9,852

Barnsley Battery.—In our November 22nd issue, p. 854, we mentioned a "Tudor" battery at the Barnsley electricity works. We are informed that the battery is of Messrs. Pritchetts and Gold's manufacture, and was put down by them.

Catalogues.—The General Electric Company (1900) have brought out a new leaflet describing their "Angold differential cut-out" for series arc lamps, for which they claim special advantages.

The "Knowledge" Diary and Scientific Handbook for 1902 contains much material of an astronomical nature, and should be very useful as a desk diary. (326, High Holborn. 3s.)

Messrs. Millington, Everitt & Co., Limited, Cambridge, have sent us some illustrated price lists of their continuous current electric motors.

The Southwark Manufacturing Company, of 28, Southwark Bridge Road, S.E., have sent us one of their price lists of hair, cotton and leather belting, and other specialities.

Cork International Exhibition, 1902.—Mr. R. A. Atkins, hon. secretary of this exhibition, writes from Municipal Buildings, Cork, to correct a statement which appeared in our last issue. The latest date for all applications, save for the Women's Section, was November 30th. Space has been very largely over-applied for by applicants from all over the British Isles, the Continent of Europe, America and Africa. All communications must be addressed to Mr. Atkins.

Dissolutions, &c.—A meeting of the Continental Water and Electrical Power Syndicate is to be held at 97, Finsbury Pavement on January 15th to hear an account of the winding-up from the liquidator, Mr. Harry Meredith.

Messrs. C. V. Fisher and A. E. Allison, electrical engineers, Cleveland Street, Doncaster, have dissolved partnership. Mr. Allison attends to debts.

Messrs. W. and H. P. Frazier (H. P. Frazier & Co., electricians, Congreve Street, Birmingham) have dissolved partnership.

For Sale.—Some gas engines, dynamos, and other electric lighting plant, are offered for sale by private treaty. The particulars of these and also of another electric lighting installation which is to be disposed of, appear in our advertisement pages to-day. The gas-driven plant, battery, lamps, &c., used for lighting an arcade at Colne is also offered for sale.

The Leigh Cable Works.—These works are now ready for business, and at the last meeting of the Tramways and Electricity Committee of the Leigh Town Council, the tender of the Anchor Cable Company, Limited (the lowest), for the supply during the ensuing 12 months of cables and accessories to the extent of £1,103 was accepted. Three members of the Committee, said to be interested in the company, did not vote.

New Electrical Wiremen's Association.—As a result of the recent meeting, it has been decided that the new Society be known by the above title. It has also been decided to meet every Saturday at 8 p.m. until further notice at the "Alma," Parson's Green Lane, Walham Green, S.W. Competent wiremen wishing to join are requested to communicate with the Secretary, New Electrical Wiremen's Association, 79, Hubert Grove, Clapham, S.W., or at the "Alma."

Trade Announcement.—The Electric Construction Company, Limited, will open a branch office at Prudential Buildings, King Street, Manchester, on or about 20th inst. Mr. Sidney Crouch, A.M.I.E.E, has been appointed the representative of the company for Lancashire, Yorkshire and neighbouring districts. Mr. Crouch has for several years represented Messrs. J. H. Holmes and Co., of Newcastle-on-Tyne, in the Manchester district.

Watertight Lampholders.—In our "Correspondence" columns last week, "Moisture" asked for a means of making an ordinary lampholder absolutely watertight at the lamp socket. Mr. Samuel Miller, of 249, High Street, Camden Town, N.W., has now sent us a specimen rubber sleeve, which he has patented and is supplying, to cover the lampholder and extend to the glass of the lamp. He states that the lamp will even burn under water when the sleeve is used. The Imperial Lighting Company of 13, Gate Street, Holborn, W.C., also supply a watertight lampholder.

ELECTRIC LIGHT AND POWER NOTES.

Bath.—The electricity supply, which failed on November 8th, failed again on the 28th, and the new switchboard, which had been brought into use, was seriously damaged. Mr. Gatehouse, the electric lighting inspector, stated that the latter, which is of American construction, broke down when switching over from one machine to another. Temporary arrangements were made to carry on the supply until a Ferranti switchboard can be installed. The T.C. last week refused to re-elect the E.L. Committee, and resolved to form a committee of the whole Council to deal with the matter. This committee has appointed an inquiry sub-committee to investigate the past history of the concern and report as to its future working, with information as to the amount of money required to put the undertaking into a thoroughly sound condition, and a management sub-committee to carry on the works from day to day until the Council shall have come to a decision.

Bloemfontein.—The T.C. recently considered the report of Mr. Hammond, the consulting engineer, on the electric light extension scheme. Mr. Ehrlich thought the Council should agree to Mr. Hammond's proposal to provide additional machinery at the cost of £13,500, the cost of mains to be added from time to time as required for consumers and for street lighting. The report was adopted.

Bristol.—The T.C. has approved the promotion of an omnibus Bill containing the extended powers for the Electrical Committee already noted by us.

Broadstairs.—The U.D.C. has agreed with the Isle of Thanet Electric Tramways and Lighting Company as to the erection and supply of arc lamps, at £13 16s. 8d. per 12-ampere lamp burning 3,000 hours per annum, and £12 per 12-ampere lamp used only in the summer.

Cardiff.—The E.L. Committee has decided to charge 1d. per unit for 50,000 units per annum, 1½d. for 35,000, and 1¼d. for 25,000 units for motive power to the Mount Stuart Dry Dock Company. The committee last week increased the salary of Mr. J. E. Teasdel, deputy electrical engineer, from £175 to £200.

Derby.—At a special meeting of the T.C. last week Mr. A. Butterworth, J.P., presented an elaborate statement with reference to the adverse balance on the working of the electric light, and pointed out that the increase in the expenditure included £2,227 for coal, £40 for oil and engine waste, £65 for renewals of street lamps, £39 for wages, £1,276 for interest, and £835 for repayments of loans—a total of £4,844 in all. The borough accountant made the depreciation and sinking fund to be 4·8 per cent. on their capital. Out of the published list of 38 electric light concerns under provincial authorities, only one (Shrewsbury) paid as large a percentage: and 1 per cent. made a difference of £1,257 to the Council. The demand for electricity, both for lighting and power, continued to increase. In March, 1900, there were 496 customers using 45,000 lamps, whereas in March, 1901, there were 636 customers using 60,000 lamps. Then the revenue showed that for the year up to March, 1900, they sold 49,265 units for £427 14s. 4d., and in the year ending March, 1901, they sold 73,889 units for £637 2s. 3d. The Council resolved to expend £3,000 for the purchase of electric motors.

Dumfries.—The E.L. Committee has received a letter from Messrs. J. and W. Purves, Edinburgh, on behalf of Messrs. Crompton & Co., electrical engineers, London, forwarding a new offer to undertake the supply of electricity to the town. The B. of T. has decided to defer consideration of the revocation of the prov. order for 12 months from June 15th last. It was decided not to consider the terms of Messrs. Crompton's offer in view of the resolution of the Council to carry through themselves the installation, and to send a deputation to Old Trafford for the purpose of obtaining information regarding Mond gas. Provost Glover stated that he had received an offer from Messrs. Brunner, Mond & Co., to lay down plant, working from 750 to 1,000 H.P., for £2,500.

Epsom.—The U.D.C.'s installation was tested for the first time on Wednesday evening, when the street lamps were switched on.

Durban.—An action brought by Marie Rampores against the Corporation for £1,000 damages, by reason of her husband having been killed by electric shock through coming in contact with an overhead lighting wire whilst working on a housetop, has been decided in favour of the Corporation, on the ground of contributory negligence.

East and West Molesey.—The U.D.C. has finally decided to rescind the motion authorising the application for a prov. order.

Elland.—The D.C. has decided to apply to the L.G.B. for sanction to borrow £16,000 for a refuse destructor and electrical installation.

Enfield.—The D.C. has given its consent to the application of the North Metropolitan Electrical Power Distribution Company, for a prov. order for the electric lighting of the district.

Farnham.—The U.D.C. has received the report of its advising engineers, Sir William Preece and Major Cardew, on the proposed installation of electricity by the Edmundson Electricity Corporation. The corporation's proposal is that the Council should arrange for a loan, the company to carry out the works under the supervision of the Council's engineer on terms to be agreed upon, and the undertaking to be leased for a period of 14 years at a rental equivalent to the amount of interest and loan repayments.

Felling.—The U.D.C. has resolved to accept the terms of the Durham County Electric Power Company, namely—that for public lighting 16 c.p. lamps be charged £2 10s. per annum; two 16-c.p. or one 32-c.p., £2 18s. per annum; that the general average per unit to private consumers should never exceed the price in Gateshead; that motive power be supplied at 1s. 6d. per unit to machines running 54 hours a week, the supply to be ready in 15 weeks; and that certain tramlines be constructed.

Frome.—The D.C. has decided to adopt the scheme of electric supply submitted by Mr. F. H. Medhurst, at an expenditure estimated at from £15,000 to £20,000.

Glasgow.—The Corporation have decided to add 31 arc lamps to those already in use for public street lighting.

Grays.—The electrical engineer, Mr. Long, reports that there have been 44 applications for a supply of electric energy, representing the equivalent of 3,533 lamps of 8 c.p.; 20 street lamps have also been connected. From October 21st to November 21st the refuse consumed in the Meldrum destructor was 151 tons, and the coal used 12½ tons. If there had been sufficient refuse, he considered that no coal would have been required.

Hendon.—On Saturday last Col. A. J. Hepper, R.E., L.G.B. inspector, opened the inquiry into the application of the D.C. for a loan of £36,400 for electric lighting purposes. As considerable opposition has been evinced towards the scheme, counsel representing the U.D.C., 600 ratepayers, the Electrical Power Distribution Company, the Midland Railway Company (whose rateable value is one-eighth of the total rateable value of the parish), the North Middlesex Gas Company, the Hendon Ratepayers' Association, and other ratepayers, were in attendance. Mr. R. Hammond, consulting engineer to the Council, gave an outline of the scheme proposed. The system was a low pressure one on the three-wire system, with 480 volts between the outers. The generating station would cost over £6,000, and there would be over 8 miles of mains. The feeders and distributing mains would cost about £12,318. The boiler house plant would cost £3,238. The cost of the engine house plant would be £3,876. No provision is made as yet for public lighting. The population of the district is about 23,000, and the rateable value £124,595. The inquiry was adjourned until Thursday, 12th inst.

Johannesburg.—The T.C. has resolved to undertake the lighting of Bertram's Township with electricity, and to utilise the plant of the Lighting Syndicate for this purpose.

Leek.—The D.C. has appointed Messrs. Burstall and Monkhouse consulting engineers to carry out an electric lighting scheme.

Leigh.—The L.G.B. has sanctioned the borrowing by the Corporation of £11,250 for electric lighting extensions.

Lewes.—The T.C. is considering the question of electric street lighting.

Llandilo.—The U.D.C. has signed the contract with Mr. Bertram Thomas for the electric lighting scheme. Mains will be laid throughout the town at a cost of £2,770.

Loughborough.—The T.C. has resolved to exercise its electrical powers and to appoint Mr. C. H. Gadsby as engineer for carrying out the works.

Mitchelstown.—A committee of the people of the town has obtained the sanction of the R.D.C. for a loan of £2,000 to carry out the electric lighting scheme.

Monmouth.—The electrical engineer, Mr. A. W. Blake, has reported to the Town Council that the plant at disposal is not sufficient to cope with the demand for lighting. The T.C. has therefore resolved upon the purchase of another alternator of 60-kw. capacity.

London.—Poplar. The Borough Council has decided to light the main roads in the Isle of Dogs and Old Ford, and two miles of side streets in other parts, with electricity.

Bermondsey.—The Finance Committee has approved of the expenditure of a sum not exceeding £1,000 for the purpose of wiring and putting in fittings to the premises of those requiring electric light from the Council's works, notwithstanding that the L.G.B. has stated that the expenditure could not properly be incurred under the Local Authorities' Expenses Act, and that the Board of Trade had expressed the opinion that there was nothing in the electric lighting order which empowered the Council to execute any work on the consumers' premises.

Hammersmith.—Owing to the number of applications received for charging the batteries of motor cars, the Borough Council has decided to establish a charging station at the electricity works, at an estimated outlay of £200; petrol car ignition batteries are to be charged at the rate of 8d. per unit, and electric cars at the rate of 3d. per unit.

Margam.—The U.D.C. is to apply to the L.G.B. for powers to borrow £7,000 for electricity works.

North Walsham.—The D.C. has agreed not to enter into negotiations with any company except the National Electric Wiring Company, Limited, until the latter has submitted a scheme of electricity supply.

Paisley.—The T.C. has agreed to borrow a further sum of £30,000 for the extension of the electric lighting undertaking.

Penarth.—The electricity works, which have been ready for some time, commenced working last week. They were erected by the Electrical Power Distribution Company.

Pencoed.—The Lighting Act has been adopted at Pencoed, and when the scheme for lighting the Great Western Railway by electricity is adopted, it is proposed to arrange with the company to light up the place by electricity.

Rochester.—A serious explosion occurred on Saturday, at an underground transforming station belonging to the Rochester and Chatham Electric Lighting Company, in the High Street, Rochester.

Rotherham.—Messrs. Kennedy and Jenkin are to prepare a report and specification for the T.C. *re* electric tramways.

Stepney.—The M.B.C. has sanctioned the expenditure of £1,440 on arc lamps, and £1,270 on the conversion of gas lamps to electric lighting in a large number of streets.

Stirling.—The T.C. has adopted a three-years' purchase system of electric wiring, as free wiring has not been a success in Stirling. A scale of charges has been adopted for the hire and hire-purchase of electric motors. In addition to the flat rate of 2d. per unit for motors, a maximum demand charge of 5d. per unit for the first hour per day, and 1d. per unit subsequently, has been introduced.

Sunderland.—The electricity undertaking is now supplying 110,185 8-c.p. lamps, with 683 consumers. The number of units to be sold this year is estimated at 2,500,000. The profit for the year ending March 31st last was £1,257, and the capital outlay was then £119,933; this has been augmented by the erection of the generating station at Hylton Road. The average price received from consumers is 3·63d. and the cost to the Corporation is 3d. The Committee now has plant for the supply of 132,000 8-c.p. lamps.

Swansea.—There have been so many applications for lighting that there is urgent necessity for the extension of the plant in readiness for next winter.

Wimbledon.—The annual accounts of the U.D.C., audited to March last, show that the receipts from the Council's electric undertakings amount to £3,731 17s. 10d., in addition to £4,028 18s. 11d. for public electric lighting. The expenditure was £7,089 11s. 10d.

Woolwich.—The Council served notice on the Blackheath and Greenwich District Electric Light Company on June 12th, 1901, of intention to purchase the Eltham undertaking at the expiration of 12 months. Shortly afterwards the company served the Council with notice of their intention to lay mains throughout the whole of the Eltham area. The approximate cost of laying these mains, and of carrying out the works connected therewith, is from £20,000 to £30,000. Under the terms of the company's order the Council objected to the company's proposals to lay these mains, which might involve the repayment by the Council of this large expenditure, together with the 38 per cent. premium provided in the purchase section. The company have appealed to the B. of T., and this appeal is now pending. The company had already expended the sum of £2,500 in the Eltham area. In order to avoid litigation, the Committee recommends:—"That the Council offer to purchase the Eltham portion of the company's undertaking for the sum of £6,000 upon condition that the company prove that the sum of £2,500 had been properly expended by them, and that the company agree to supply the Council with electricity in bulk upon terms to be agreed." The M.B.C. adopted the Committee's recommendations.

Negotiations are pending with the L.S.B. for the lighting of the Board Schools in the borough by means of electricity

TELEGRAPH AND TELEPHONE NOTES.

The Australian Cable.—The telegraph ship *Scotia* arrived off Gravesend on 6th inst. after her long voyage from Australia. She has been with the *Anglia* laying the final link in the cable which now runs from England through the Mediterranean and the Red Sea, thence to the Seychelles and Mauritius, and then *viâ* Rodrigues and Cocos Island to Perth in Western Australia.

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Telegraphic Interruptions and Repairs:—

Cables.	Interrupted.	Repaired.
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Para-Maranham	.. March 1, 1900 ..	..
Marseilles-Barcelona	.. Dec. 4, 1901 ..	..
New Brunswick-Prince Edward Island ..	.. Dec. 10, 1901 ..	..
Landlines:—		
"*Via* Hanekin" on Persian territory ..	.. Feb. 24, 1900 ..	..
Communication with Baranquilla and Cartagena	Dec. 8, 1900 ..	..
" towns of Venezuela	.. Oct. 31, 1900 ..	..

The Telephone Agreement.—The Postmaster-General last Friday received a deputation from the L.C.C., who protested against the terms of the new Post Office telephone scheme, and complained that it did not provide the effective competition with the National Telephone Company's service which the public had been led to expect. Lord Londonderry, in reply, as we gather from the *Times* summary, admitted that the competition which was being instituted with the National Telephone Company was not the kind of competition carried on in the commercial world by rival traders. Such a competition, for reasons which he set forth at length, he held to be undesirable in the public interest. The London public could not be well served without an arrangement for securing co-operation between the two systems, and the arrangement arrived at after a great deal of negotiation secured such a co-operation, while at the same time it deprived the company of the privileges it had hitherto enjoyed of an unregulated monopoly. It had also been agreed, when the company's licence expired in 1911, to purchase so much, and so much only, of the plant of the company as was suitable to the requirements of the Post Office. As to the rates to be charged, there was no foundation whatever for the allegation that they were unduly high, or that the interests of the public of London had been sacrificed to those of the company's shareholders. It was necessary that the service should be self-supporting; it was in the nature of an experiment, and it was always easier to reduce the charges for a public service than to increase them. Lord Londonderry proceeded to point out that no comparison could justly be instituted between the rates charged in the London area, with its population of over 6,000,000, and the rates in provincial towns, and to lay stress on the provision made for the class who only require a limited user of the telephone service. Finally, he reminded the deputation that the rates would be open to revision in 1905.

Vocabulary.—The Administration of the Argentine Republic are considering the advisability of proposing to the International Telegraph Conference to be held next year in London, the adoption of the vocabulary of Mr. Nicholson, Superintendent of the Rio Plata Telegraph Company. The system was invented in 1895, and it is claimed for it that it considerably reduces the time occupied in transmission. A notice of the vocabulary has appeared in the Electrical Review.

CONTRACTS OPEN AND CLOSED.

OPEN.

Amsterdam.—December 18th. Tenders are invited by the Netherlands Ministry of the Colonies for the supply of telegraphic apparatus.

Belgium.—March 1st. The municipal authorities of Ghent are inviting tenders until the March 1st, 1902, for the concession for an electric lighting installation. Tenders are to be sent by registered letter to La Collège, Echevinàl, Ghent, while full particulars can be obtained from Le Bureau des Travaux.

Birkenhead.—The Corporation Tramways Committee invite tenders for a supply of the following stores for the 12 months ending December 31st, 1902:—Poplar wood blocks; cast-iron brake blocks and other castings; motor grease; river sand; cleaning cloths; sponge cloths and brushes.

Egypt.—January 18th. Electric lighting of Suez and Damanhour. Particulars from the Minister of Public Works, Cairo.

France.—December 16th. Estimates will be opened at the Hotel de Ville, Surisnes, France, on 16th prox., for the supply of three electric units and pumps, for the purpose of raising water in the departmental drainage station; and at the Hotel de Ville, Courbevoie, France, on same date, supply of two electric groups and pumps for same purpose. Information in each case from the municipality.

France.—December 17th. Tenders are being invited until the 17th inst., by the French Post and Telegraph authorities in Paris, for the supply of 15 kilometres of iron pipes for pneumatic pipe lines. Tenders are to be sent to Le Sous Secretariat d'Etat des Postes et des Telegraphs, 103, Rue de Grenelle, Paris, whence particulars may be obtained.

Hornsey.—January 15th. Pipework and mechanical coal-handling plant for electricity works for the U.D.C. See "Official Notices" December 6th.

Horsham.—December 17th. Meters (D.C.) and cut-outs for the electricity works. See "Official Notices" December 6th.

Kirkcaldy.—January 8th. Piping, pumps, feed heater, &c., for electricity works. See "Official Notices" to-day.

Leigh.—The Corporation Electrical Engineer (Mr. J. Foster) has been instructed to advertise for tenders for (1) erection of a boiler house; (2) one 400-H.P. water-tube boiler; (3) one set of condensing and water cooling plant; and (4) one dynamo and two feeder panels for main switchboard.

Leith.—December 16th. Boilers and economiser, condenser, cooling tower, pipes, dynamo and feeder panels. See "Official Notices" December 6th.

London.—December 19th. Electric fire alarm system for the N.W. Fever Hospital, Hampstead, for the Metropolitan Asylums Board. See "Official Notices" November 29th.

Maidenhead.—December 13th. Steam piping, transformers, motor-generators, battery, switchboard, arc lamps, cable work, and crane for electric lighting works. See "Official Notices" November 22nd.

Maidenhead.—December 13th. Stoneware conduits for electric mains, arc lamp-posts, &c., for T.C. Consulting engineers Burstall & Monkhouse.

Maidstone.—December 19th. Electric light fitting and wiring at various public buildings for the Corporation. See "Official Notices" December 6th.

Manchester.—December 17th. Tenders are invited for the construction of sections 1 and 3 of a subway for electric cables in Stuart Street, Cavendish Place and Queen Street, Bradford.

(*Continued on page* 1017.)

SPRAGUE MULTIPLE UNIT SYSTEM.

As Applied on the Boston Elevated Railway.

By FRANK J. SPRAGUE.

The multiple unit system, reduced to commercial practice in Chicago only four years ago by the writer, is now recognised as the preferable method of operating electric railways on all congested service where there are frequent trains of variable length, and the need is felt of quick and economic handling of units at high schedule speeds. It has received the highest practical endorsement, the adoption already of over 300,000 H.P. of equipment, and it is reasonably safe to say that for the class of service for which it is designed, no other method of train operation can approach it for effectiveness.

The system is really a method of train operation and control, by means of which cars are equipped with motors and motor-controllers, individual to these cars, so that they may be united with any number of other cars similarly equipped, or with any number which have no motors, into a train of any length, and operated from as many points as desired through a controlling line common to all cars. The

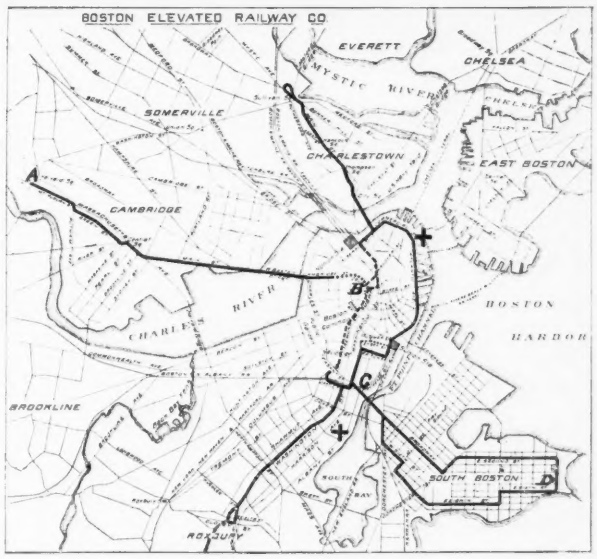

Fig. 1.—Map of Boston Elevated Railway.

Fig. 2.—Three-Car Train ascending 5 per cent. Gradient from Subway.

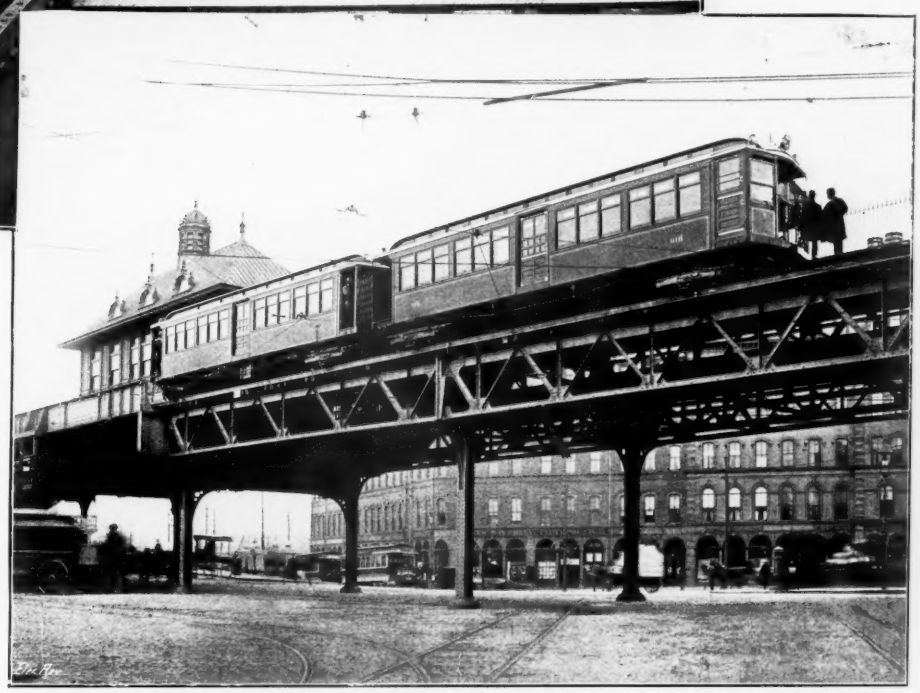

Fig. 3.—Two-Car Train at City Square Station.

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Communication with Baranquilla and Cartagena	Dec. 8, 1900 ..	..
" towns of Venezuela	.. Oct. 31, 1900 ..	..

The Telephone Agreement.—The Postmaster-General last Friday received a deputation from the L.C.C., who protested against the terms of the new Post Office telephone scheme, and complained that it did not provide the effective competition with the National Telephone Company's service which the public had been led to expect. Lord Londonderry, in reply, as we gather from the *Times* summary, admitted that the competition which was being instituted with the National Telephone Company was not the kind of competition carried on in the commercial world by rival traders. Such a competition, for reasons which he set forth at length, he held to be undesirable in the public interest. The London public could not be well served without an arrangement for securing co-operation between the two systems, and the arrangement arrived at after a great deal of negotiation secured such a co-operation, while at the same time it deprived the company of the privileges it had hitherto enjoyed of an unregulated monopoly. It had also been agreed, when the company's licence expired in 1911, to purchase so much, and so much only, of the plant of the company as was suitable to the requirements of the Post Office. As to the rates to be charged, there was no foundation whatever for the allegation that they were unduly high, or that the interests of the public of London had been sacrificed to those of the company's shareholders. It was necessary that the service should be self-supporting; it was in the nature of an experiment, and it was always easier to reduce the charges for a public service than to increase them. Lord Londonderry proceeded to point out that no comparison could justly be instituted between the rates charged in the London area, with its population of over 6,000,000, and the rates in provincial towns, and to lay stress on the provision made for the class who only require a limited user of the telephone service. Finally, he reminded the deputation that the rates would be open to revision in 1905.

Vocabulary.—The Administration of the Argentine Republic are considering the advisability of proposing to the International Telegraph Conference to be held next year in London, the adoption of the vocabulary of Mr. Nicholson, Superintendent of the Rio Plata Telegraph Company. The system was invented in 1895, and it is claimed for it that it considerably reduces the time occupied in transmission. A notice of the vocabulary has appeared in the Electrical Review.

CONTRACTS OPEN AND CLOSED.

OPEN.

Amsterdam.—December 18th. Tenders are invited by the Netherlands Ministry of the Colonies for the supply of telegraphic apparatus.

Belgium.—March 1st. The municipal authorities of Ghent are inviting tenders until the March 1st, 1902, for the concession for an electric lighting installation. Tenders are to be sent by registered letter to La Collège, Echevinal, Ghent, while full particulars can be obtained from Le Bureau des Travaux.

Birkenhead.—The Corporation Tramways Committee invite tenders for a supply of the following stores for the 12 months ending December 31st, 1902:—Poplar wood blocks; cast-iron brake blocks and other castings; motor grease; river sand; cleaning cloths; sponge cloths and brushes.

Egypt.—January 18th. Electric lighting of Suez and Damanhour. Particulars from the Minister of Public Works, Cairo.

France.—December 16th. Estimates will be opened at the Hotel de Ville, Surisnes, France, on 16th prox., for the supply of three electric units and pumps, for the purpose of raising water in the departmental drainage station; and at the Hotel de Ville, Courbevoie, France, on same date, supply of two electric groups and pumps for same purpose. Information in each case from the municipality.

France.—December 17th. Tenders are being invited until the 17th inst., by the French Post and Telegraph authorities in Paris, for the supply of 15 kilometres of iron pipes for pneumatic pipe lines. Tenders are to be sent to Le Sous Secretariat d'Etat des Postes et des Telegraphs, 103, Rue de Grenelle, Paris, whence particulars may be obtained.

Hornsey.—January 15th. Pipework and mechanical coal-handling plant for electricity works for the U.D.C. See "Official Notices" December 6th.

Horsham.—December 17th. Meters (D.C.) and cut-outs for the electricity works. See "Official Notices" December 6th.

Kirkcaldy.—January 8th. Piping, pumps, feed heater, &c., for electricity works. See "Official Notices" to-day.

Leigh.—The Corporation Electrical Engineer (Mr. J. Foster) has been instructed to advertise for tenders for (1) erection of a boiler house; (2) one 400-H.P. water-tube boiler; (3) one set of condensing and water cooling plant; and (4) one dynamo and two feeder panels for main switchboard.

Leith.—December 16th. Boilers and economiser, condenser, cooling tower, pipes, dynamo and feeder panels. See "Official Notices" December 6th.

London.—December 19th. Electric fire alarm system for the N.W. Fever Hospital, Hampstead, for the Metropolitan Asylums Board. See "Official Notices" November 29th.

Maidenhead.—December 13th. Steam piping, transformers, motor-generators, battery, switchboard, arc lamps, cable work, and crane for electric lighting works. See "Official Notices" November 22nd.

Maidenhead.—December 13th. Stoneware conduits for electric mains, arc lamp-posts, &c., for T.C. Consulting engineers Burstall & Monkhouse.

Maidstone.—December 19th. Electric light fitting and wiring at various public buildings for the Corporation. See "Official Notices" December 6th.

Manchester.—December 17th. Tenders are invited for the construction of sections 1 and 3 of a subway for electric cables in Stuart Street, Cavendish Place and Queen Street, Bradford.

(*Continued on page* 1017.)

SPRAGUE MULTIPLE UNIT SYSTEM.

As Applied on the Boston Elevated Railway.

By FRANK J. SPRAGUE.

The multiple unit system, reduced to commercial practice in Chicago only four years ago by the writer, is now recognised as the preferable method of operating electric railways on all congested service where there are frequent trains of variable length, and the need is felt of quick and economic handling of units at high schedule speeds. It has received the highest practical endorsement, the adoption already of over 200,000 H.P. of equipment, and it is reasonably safe to say that for the class of service for which it is designed, no other method of train operation can approach it for effectiveness.

The system is really a method of train operation and control, by means of which cars are equipped with motors and motor-controllers, individual to these cars, so that they

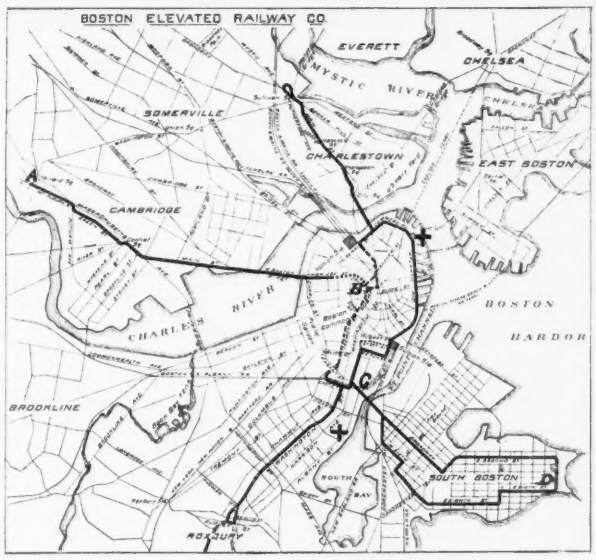

Fig. 1.—Map of Boston Elevated Railway.

Fig. 2.—Three-Car Train ascending 5 per cent. Gradient from Subway.

Fig. 3.—Two-Car Train at City Square Station.

may be united with any number of other cars similarly equipped, or with any number which have no motors, into a train of any length, and operated from as many points as desired through a controlling line common to all cars. The

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number of cars, their sequence, and their end-to-end relation, are matters of indifference, and the character and capacity of the equipment are dependent upon the schedule specified, varying from every car, where the highest schedule is required, down to two cars in a train.

It is evident that such a system lends itself to every condition of congested passenger service. The similarity of equipment ensures flexibility of train operation, and provides a motive power proportioned to the requirements. Locomotive operations are abolished, trains can be reversed at any cross-over, and traffic concentrated on any section of a road. The safe interval between trains is dependent upon the maximum speed and the power of control, and hence both the time and the distance intervals between trains can be reduced.

With high-power equipments any required schedule up to the maximum becomes possible, and the number of cars in service can be made a minimum. Where a crowded system has main tracks with branches, units for the different branches can be combined on the main line, and split up at junctions, and *vice versâ*.

Fig. 4.—Sprague Folding Cab.

The operation of the system is simple. Every unit being self-contained, and every aggregation of such being simply an extension in the length of the unit without changing its general character, operation becomes habit. Like hand and like train movements exist whatever the combination of units. Protected by automatic devices, a man of ordinary intelligence can handle trains with less trouble, so far as the electrical apparatus is concerned, and with less instruction than is required for the air brake. The highest safety being essential, the system of operation obviously provides it. In case of failure of brakes, the machines throughout the entire train can be safely reversed. The current input to the machines is automatically limited on each one to its safe capacity. In case of accident to an operator, the entire power is instantly removed from the train, and if the master switch on the leading car is inoperative the train can be operated from either end of any other. In fogs and on slippery rails, a fixed schedule can be maintained more effectively because of the lower maximum speed, and the less distance travelled in braking.

The multiple unit system has now become a necessity, for without it some of the modern railway work would be impossible. In the history of transportation no more difficult problem has been undertaken than the inauguration of the elevated service on the lines of the Boston Elevated Railway. The transportation problem in Boston is most complex. The

Fig. 5.—Master-Controller, Engineer's Valve, and Air Gauge.

streets are narrow and crooked, and the inner terminus for most of the travelling public is a restricted area and extremely crowded. The congestion of the car service was considerably removed by the construction of the "Subway," built by the Rapid Transit Commissioners of Boston and leased to the street railway company. This afforded temporary relief, but it was early found to be inadequate for Boston's growing needs.

The necessity for improved service being seen, plans were made and work actively prosecuted—one result being the elevated system shown in the accompanying map (fig. 1)—all of which, except the portions marked A B, crossing the Charles River, and C D, to South Boston, is built and in operation, with about 15 miles of track. Without personal inspection of the road, the boldness of the conception

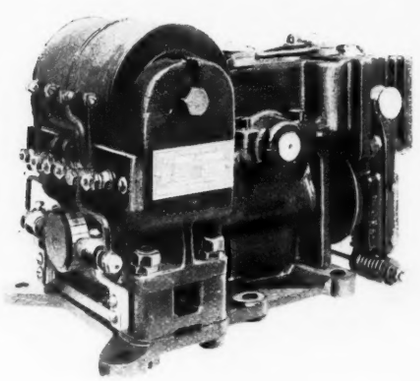


Fig. 7.—Pilot Motor detached from Main Controller.

can hardly be appreciated. On a trifle over 10 miles of track, the western route alone, there is an aggregate of 3,395° of curvature, and the longest stretch of straight track is less than ·28 mile. If the track were laid out with this amount

of curvature from a common centre, it would complete nearly 10 circles. Many of the curves are as low as 90 ft. radius. The ascending grades are as high as 5 per cent., or 264 ft. per mile ; the descending grades as much as 422 ft. per mile, or 8 per cent. (fig. 2).

Of the present railway tracks, about 2·27 miles are underground in the subway, and the remainder on elevated structure at each end of the road.

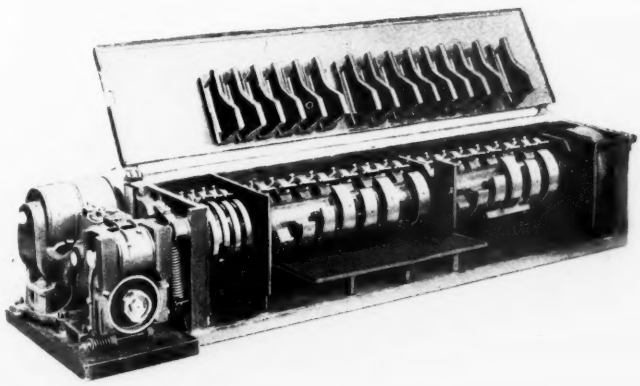


Fig. 6.—Main Controller, Open for Inspection.

Opening of Road.

Surface cars had been run on the subway tracks now occupied by the elevated lines since the subway was opened. In order to make the track connections to the elevated structure, and to reconstruct the subway platforms for elevated trains, it was necessary to discontinue the surface cars on the tracks in the subway. With a view to causing as little inconvenience to the public as possible, this change was made during a week-end. On Saturday evening, June 8th, at 8 o'clock, the last surface car was run over these tracks, and on Monday morning, June 10th, at 5.30 o'clock, the elevated service was begun. Over 1,200 men were busied during this time in making the change. In addition to perfecting the track, signals, platforms and equipment necessary to be placed in operation, the largest task in this limited time was to re-arrange the operation of the surface lines, and to provide for the changed conditions of traffic. 1,600 surface cars are run on the Boston system. During the change-over temporary schedules and lines were in operation. This would not have been possible during the middle of the week, as the street traffic would not permit the great number of cars to be on the streets.

The starting of the elevated service involved the changing of 51 lines of surface cars and the inauguration of 23 transfer points. It also called for the provision of a new transfer system, requiring the instruction of no less than 2,500 conductors of the surface lines. Of the 850,000 daily passengers, fully 45 per cent. were diverted from their accustomed routes of travel. On their opening day it is estimated that 66 elevated cars carried 300,000 people, and 100,000 transferred at the Sullivan Square terminus.

When this service was undertaken not one of the trainmen had ever made a complete trip over the road, and few had ever had any experience with train service. The whole equipment was entirely new, and last, but not least, the majority of the patrons had never ridden on an elevated train.

The extraordinary conditions surrounding the operation of these trains rendered every possible safeguard imperative, so that every improvement conducive to safety has been adopted. The guard rails are of 100 lbs. section, and are rigidly fastened. They are placed somewhat higher than the track rail, so that the possibility of derailment is practically eliminated. The strength and rigidity of the structure is exceptional (fig. 3), and the excellence of the details of track alignment and special work is notable. The movement of trains is governed completely by interlocking stations and by automatic block signals of the electro-pneumatic type. One of the track rails is insulated from the other, so that a track circuit signal system can be used. The cars are all provided with automatic trips, so that if a train is run past a stop signal, the air on the train is immediately thrown into "emergency."

The question of control and equipment of the trains was one which called for the most exacting consideration. It was early appreciated that more than the usual motive power should be used. Equipment on more than one car in the train and the "multiple unit" system were considered imperative. In order to determine the safest and best system for their use, it was decided to invite the installation of three different equipments on test trains to be run over the most difficult portion of the road—the subway. The tests and investigations made were the most complete and elaborate ever undertaken in competition for an electric railway equipment. The contract for the controlling system was finally awarded the Sprague Electric Company, and this was followed by two additional contracts, aggregating 150 motor cars, of which 100 are already installed.

For the construction of the cars and the installation of all apparatus on them most careful and exacting specifications were made. The cars are substantial and very solidly built; the seats are longitudinal, and centre doors are used. The platforms are longer than customary. The familiar "Sprague" folding cab (fig. 4) is used for the motorman and operating apparatus. It permits the gates on each side of the platform to be of the same size, and gives free access across the platform. The cars seat 48 passengers ; 80 more can comfortably stand up. Both motor and trailer trucks are solidly built and of heavy construction. The motor axles are 6½ in. diameter at centre with 7½ in. wheel-fits. The wheel base of the motor truck is 6 ft., and the wheels 33 in. in diameter.

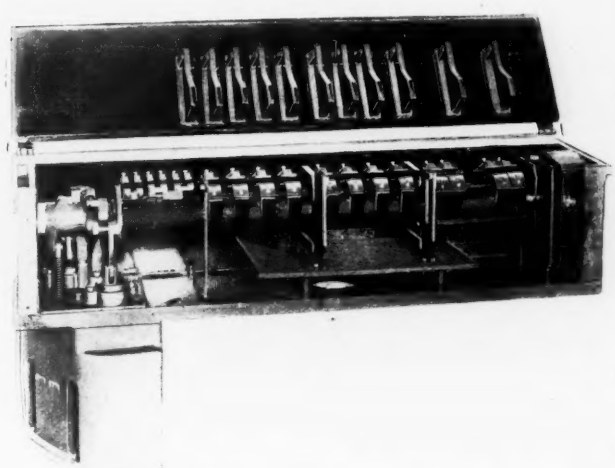


Fig. 8.—Main Reverser, Open for Inspection

The wheel base of the trailer truck is 5 ft. and the wheels 30 in. in diameter. The wheels are steel-tired, and the gears solid and pressed on the axles. Automatic couplers of extra heavy construction are used. Each car is equipped with two 150-H.P. motors, with side bar suspension. They are rights and lefts, so that the commutators are on the same side to permit of ready inspection.

The air-brake system is that of the Christensen Engineering Company. The motor-driven compressor has a capacity of 20 cubic ft. per minute to a pressure of 90 lbs. The engineer's valves have excess pressure adjustment (fig. 5). The governors are of the equalising type, and control all of the compressors in a train. The cars are heated and lighted electrically.

The multiple-unit control equipment is of the Sprague type. The working apparatus is located in a compartment under a portion of the seat at one side of the car. This compartment is open through the bottom of the car. Complete isolation of working currents from the inside of cars is therefore secured, with all the advantages of ready and efficient inspection which such location ensures. The protection and isolation of the car wiring is a matter to which especial attention has been given. It was realised that the current value of any short circuit would be in excess of any reached in any service existing elsewhere, and that such short circuit might be hazardous. The current is collected from four contact shoes carried on long wooden shoe beams on the trucks, and the main car wiring is led to each shoe through a detachable shoe fuse. The shoe fuse clears any accidental "ground" either on the car or by a contact shoe. From the junction of the contact shoe leads the main wiring extends to a protected compartment in the hood at one end of the car, where the taps are made for lights, heat, air and control apparatus, to the main switch, then back to an enclosed main fuse of the "Noark" type, located under the car; then to the control apparatus and motors.

All of the truck, car and motor wiring is of special high-grade 3,000-volt insulation. It is removed from all vibration as far as possible, and enclosed for mechanical protection. The controller equipment for each car is made up of five component parts:—a main circuit-breaking reverser for determining direction of movement; a main controller for determining speed by variation of resistance and grouping of motors; two master switches connected to switch lines for determining the movement of the main controller and reverser; a secondary controlling train line terminating in couplers at each end of the car; and a reversible jumper for connecting up the train lines on the several cars. In addition there is a set of relays and the throttle. These several parts are shown in the accompanying figures.

Main Controller.

The main controller (fig. 6) is of an "ironclad" type. All cables are led to bolted terminals insulated on slate, and connections are made outside the controller. The main contact segments on the cylinder are provided with removable 1¼-in. copper tips, and each carries only the current of one motor. The contact fingers are screw adjusted, and are provided with springs of substantial design, reinforced by a shunt of leaf copper. The finger bases are cast solid with the terminal studs. The arc deflectors are of reconstructed granite, which combines in a most efficient way high insulation and heat conduction. The control limit contacts and segments are isolated from the main contacts by a vulcabeston partition. All exposed metal surfaces, other than contact surfaces, in the interior of the controller, are covered by insulation, and are finished hard and smooth. The blow-out coil is of simple and substantial construction, of liberal dimensions, and protected from working contacts. Means are provided for adequate ventilation of contacts and coil. The insulations on the shaft are double-keyed, to prevent possible loosening, and are set under pressure.

The pilot-motor (fig. 7), which drives this main controller spindle, is rigidly bolted to the controller base, and is removable as a whole, or the fields can be removed separately. It drives the controller by a stepped movement through a powerful spring and locking pawl. These are of the most efficient design, to ensure "quick make" of contacts, and to secure positive notching. The gears run in an oil chamber. The armature support and shaft are forged from one piece of steel. The pilot-motor armature is so made as to secure rigidity of construction as well as protection of the windings. The commutator is of copper, insulated with mica, and the brushes are of carbon, with automatic feed. All coil terminals are of heavy copper, securely fastened, with means for bolting the connecting wires.

Reverser.

The reverser (fig. 8) is of the same "ironclad" type as the controller. The contact plates, fingers, and finger bases, deflectors, bearings, and blow-out coils are interchangeable with those of the controller. In addition to the motor-reversing contacts, the reverser has a muffled double "line break" isolated by vulcabeston partitions from both the motor and the limit contacts. The reverser coils are wound with a liberal margin above service requirements, and are effective between 300 and 600 volts. The plungers are kept central, and guided by phosphor-bronze rods. The reverser is brought to "open" by a powerful eccentric spring connection, and the link connection to reverser cylinder is constructed so that the reverser is "dead beat" when open. Provision is made for the release of the cylinder from the driving mechanism for the purpose of ready inspection.

(To be continued.)

THE ELECTRIC TRAIN CONTROL SYSTEM ON THE GREAT NORTHERN AND CITY RAILWAY.

Electric traction is now being applied on all the new railways in London, and seems destined at no distant date to supersede the steam locomotive on all City and suburban lines. One of the latest lines to adopt electricity as a motive power from the outset is the Great Northern and City Railway, which will run from Finsbury Park to Moorgate Street, a distance of some 3½ miles, with three intermediate stops.

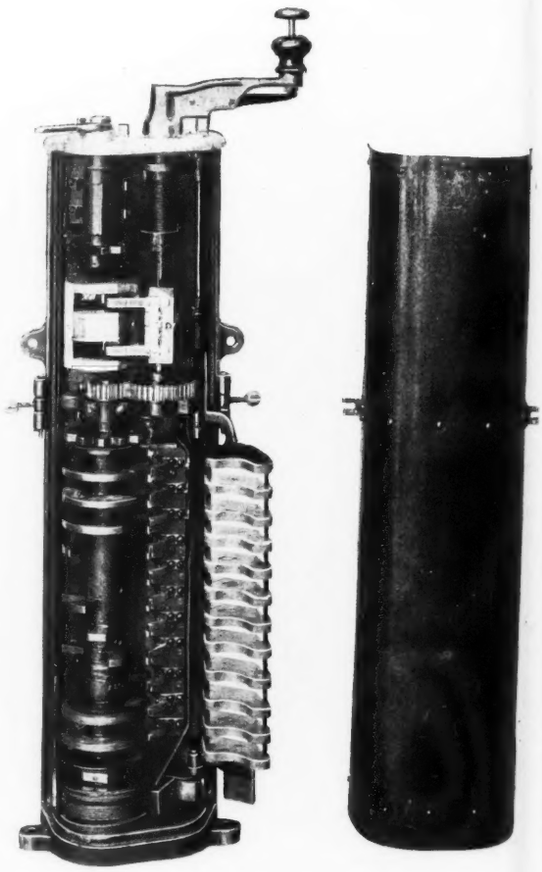


Fig. 1.—Master Controller, open, and cover.

To deal with the heavy passenger traffic between the City and suburbs on this line, it is necessary to have a rapid and frequent service of trains, and as the stations are comparatively near together, it is essential to employ a high rate of acceleration.

Another requirement of the line is that the train must be capable of operation in either direction and from either end, so that the time and space required for the shunting of a locomotive at the crowded termini may be avoided.

After a thorough investigation of the merits of the different systems, the Great Northern & City Railway Company have decided to equip their trains with the master control system of the British Thomson-Houston Company, Limited, which is specially designed to meet the above requirements.

The trains will each weigh about 200 tons when normally loaded, and will consist of seven coaches in all, of which three—the centre and two end ones—will each be equipped with two motors.

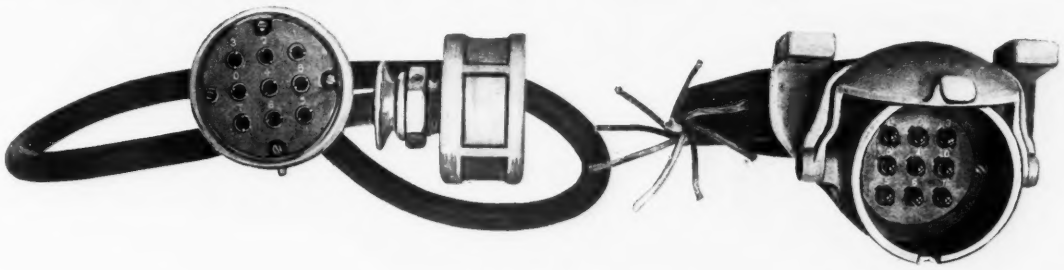


Fig. 4.—Coupler Socket and Plug.

The motors, each of which has a rated capacity of 125 h.p., are of the British Thomson-Houston Company's well-known type, with all the latest improvements, including special arrangements for ensuring the most perfect ventilation. The motors and control system are the same as those which have been adopted by the Manhattan Elevated Railway, of New York, after the most rigid examination and exhaustive trials of their capabilities. Two trains equipped with this system are now in satisfactory operation on the Central London Railway.

The master control system consists in general of two parts; first, a number of electrically operated switches, called "contactors," constituting the series-parallel motor controller, which effect the different combinations of the motors, and vary the starting resistance in circuit with them, and a separate electrically-operated reverse switch; second, two master controllers, one located at each end of each motor car, which operate the motor controlling switches and reverse switch. A cable connected to each master controller, and to the electrically-operated switches, runs the entire length of the train, whether the cars are motor cars or trailer coaches, with suitable couplers for connecting the cars.

The synchronous action of the motor controllers on all the cars with the movement of the master controller handle, ensures similar resistance connections and motor combinations on all the cars at all times. The position of the master controller handle indicates to the operator the exact position of the motor controllers on all of the cars, the proper number of points being provided on the cap plate. The rate of movement of the motor controllers, and consequently the amount of current taken by all of the motors is, therefore, under his immediate control, and the motorman is able at will to instantly utilise the full power of the motors in either direction in an emergency.

In case the power circuit is momentarily interrupted for any reason, the system of control provides for the immediate restoration of the motor and resistance connections which were in effect immediately preceding such interruptions, being equivalent in this respect to the ordinary hand controller. All current for the operation of the motor controllers on each of the different cars passes through the single master controller under the immediate control of the motorman.

The interruption of current to the motors in the off position of the motor controller is ensured by providing three separate electrically-operated switches connected in series, any one of which has capacity to open the circuits. If the train should break in two, the current would automatically and instantly be cut off from the motors on that part of the train not under the control of the motor-man, while his ability to control the front part of the train would not be affected.

When the master controller is thrown off, both "positive" and "negative" connections are cut off from the operating coils of the motor control switches and none of the train wires, or any of the wires in the train line cables are "alive."

For reversing the motors the master controller is provided with a separate reversing handle, and a mechanical interlocking device prevents this reversing handle from being thrown unless the main

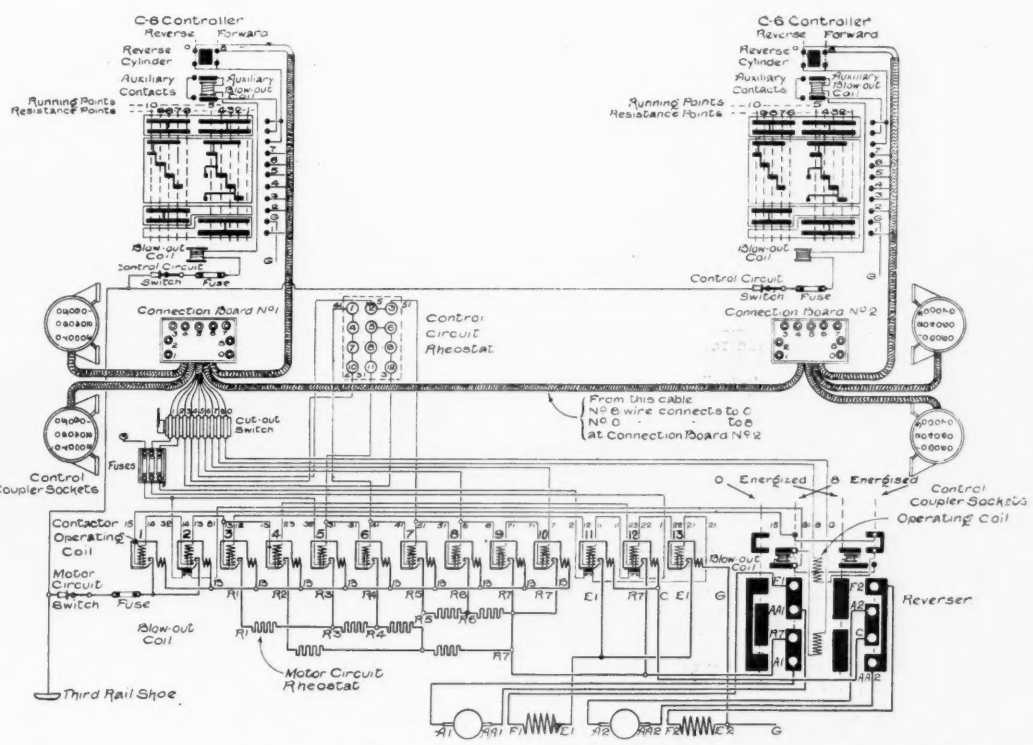


Fig. 5—Connections for Type M Train Control, with Two C-6 Controllers and Two 160-h.p. Motors.

handle is in the off position. Moving this reverse handle either forward or back makes connections for throwing an electrically-operated reverse switch, called the "reverser," to either "forward" or "reverse" position. The reverser is electrically interlocked, so that it cannot be thrown when the motors are taking current.

The operating circuit is so arranged that unless the reverse switch is thrown for the direction of car movement indicated by the master

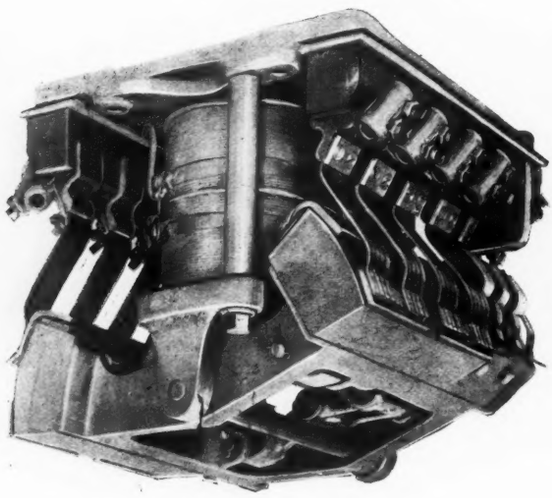


Fig. 3.—Reverser.

controller reverse handle, it will be impossible to operate the contactors and get current through the motors on that particular car. A cut-out switch is provided on each car, so that in an emergency all of the contactors on that car may be disconnected from the control circuit.

The control operating current per car at 550-volt line potential is about 2 5 amperes for an equipment for two 160-h.p. or four 80-h.p. motors. The total weight of control apparatus for this equipment is approximately 2,200 lbs.

The following is a brief description of the various parts which make up a control equipment:—

Master Controller.—The master controller, which is shown in fig. 1 is similar to the ordinary street car controller in method of operation and appearance, although considerably smaller. Separate power and reverse handles are provided, as experience has led to the general use of this arrangement in preference to the movement of a single power handle in opposite directions.

All current for the operation of the contactors passes through the single master controller in use, which takes current directly from the line. A magnetic blow-out is provided similar to that used on standard tramway controllers.

The handle for operating the reverser is located at one side, and can only be removed in the intermediate or off position of the reversing switch. As the power handle is mechanically locked against movement when the reverse handle is removed, it is only necessary for the motorman to carry the reversing handle when changing from car to car.

Electrically-Operated Switch or "Contactor."—Each electrically-operated switch, called "contactor," (see fig. 2) consists of a movable arm carrying a finger which makes contact with a fixed terminal finger, and a coil for actuating the arm when supplied with current from the master controller. The switch is so designed that the motor circuit is closed only when the current is flowing through the coil; and gravity, combined with the spring action of the finger, causes the switch to open immediately the master controller circuit is interrupted. The switch has an efficient and powerful magnetic blow-out, which will effectually disrupt the power circuit under conditions far exceeding normal operation. The different switches are practically identical, and the few parts which are subjected to burning and wear are so constructed as to be readily renewable. They are located in a small compartment of the motor car, where they can easily be inspected.

Motor Reversing Switch or Reverser.—The general design of this switch, called the "reverser," is shown in fig. 3, and is somewhat similar to the ordinary cylindrical reversing switch, with the addition of the electro-magnets for turning it to either the forward or reverse position, the operating coils being the same as the ones used on the motor control switches. The reversing switch is placed in the same compartment as the contactor switches.

Motor Circuit Switch and Fuse.—For the purpose of disconnecting the motors on any particular car, a switch is provided for opening the main circuit between the third rail shoes or trolley and the motor control. Between this switch and the motor control, for automatic protection of the apparatus, there is also provided either an automatic circuit breaker or an enclosed fuse, depending upon the character of the service.

Control Cut-Out Switch.—This switch is provided so that it may be possible to cut out all of the switch-operating coils on any car, and it can be located in any convenient and desirable position on the car.

A number of small enclosed fuses, mounted on a single block, are placed in the control circuit at such points as to efficiently protect the control apparatus.

Switch for Master Controller.—A small quick-break single-pole switch and separate fuse are provided in the supply circuit for the protection of each master controller. When this switch is open, all current is cut off from the entire control system through the particular master controller.

Control Cable Coupler.—The coupler, or "jumper" (see fig. 4), connecting the control cable between the coaches, consists of a socket attached to the car, containing a number of insulating metallic contacts connected to the train wires, and of a removable plug containing corresponding insulated contacts. The plugs connect, by a flexible cable, to corresponding terminals in the sockets on adjacent cars. The parts subject to wear are readily replaceable.

The couplers are provided with spring catches, which ensure their remaining in contact under normal conditions, but permit them to automatically release in case the train breaks.

Control Cable.—A special flexible cable made up of different coloured individual insulated conductors is used whenever possible to make control circuit connections between the various pieces of apparatus, a similar cable having an outside rubber covering being used for the "jumper" connection between the coupler plugs.

Rheostats.—The resistance portion of the rheostats consists of open cast-iron grids, which are assembled in an iron frame.

The grids are insulated from each other and from the supporting frame by mica, making the entire resistance fireproof.

Trailer Coach Equipment.—The only apparatus necessary on a trailer coach, which is operated between two motor-cars, consists of the control circuit coupler sockets connected by special control cables.

The approximate weight of apparatus required for each trailer car is 100 lbs.

On the G.N. & C. line the trailer coaches are not equipped with master controllers, but where the conditions require it, every coach of a train, whether a motor car or a trailer coach, may be thus equipped, so that the train may just as readily be operated whether there is a trailer coach or a motor car at the front.

Special Features.—This system of control being composed of individual electrically-operated switches, which may be located in any available space, can be readily adapted to many classes of service other than train operation. The small space occupied by master controller, and the ease with which it may be operated, makes this system desirable in some cases for large locomotives, heavy hoists, or other classes of severe direct current service requiring a controller easily operated, or one which may be located at a considerable distance from the motors.

In some instances the ordinary directly operating controllers may be found to occupy too much valuable cab space, and the

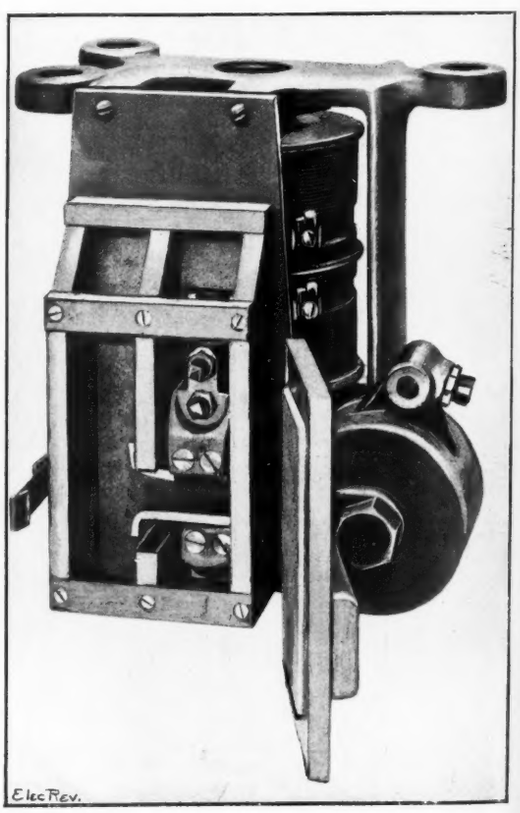


Fig. 2.—"Contactor."

master control system may be substituted, and considerable space saved thereby.

Being composed of a number of separate switches, it is much more flexible than any system in which a large cylinder is used, operated by means of a motor or other device. The rapidity with which the "contactors" operate, and the blow delivered at the contacts, ensure the removal of any roughness due to arcing, and the design of the switch provides for a peculiar rubbing action which

greatly reduces the liability of sticking. On the other hand, a cylindrical controller, which must necessarily revolve at moderately slow speed, would strike the contact fingers with less force and be much more liable to weld.

There is but one style of burning tip for both movable and stationary contacts, and the number of spare parts required is, therefore, very small. Only one form of operating coil is required for both the "contactors" and the reverse switch.

No current limiting device is used, as conditions of operation vary to a great extent, due to the variations in train load, grades and conditions of track, and provision must be made for accelerating accordingly. This system permits the same manipulation of the train as of an ordinary tramcar, and the motorman has direct control of the motors without the intervention of any automatic devices.

THE WESTINGHOUSE ELECTRO-PNEUMATIC SYSTEM FOR THE CONTRO OF ELECTRIC TRAINS.

THE requirements of the suburban railway passenger are peculiarly exacting. He must have a means of transit from the city work centres to his suburban home, which is not only cheap, but which will give high average speeds with frequent stoppings; the trains must run frequently, have rapid acceleration at starting, and quick, yet gentle, braking at stopping. Such conditions cannot be economically fulfilled by a railway system whose rolling stock consists of trains of many carriages drawn by steam locomotives. Practice has shown that the substitution of the electric locomotive for the steam locomotive is followed by vastly improved operating economies. But the best results possible with electric traction are not by any

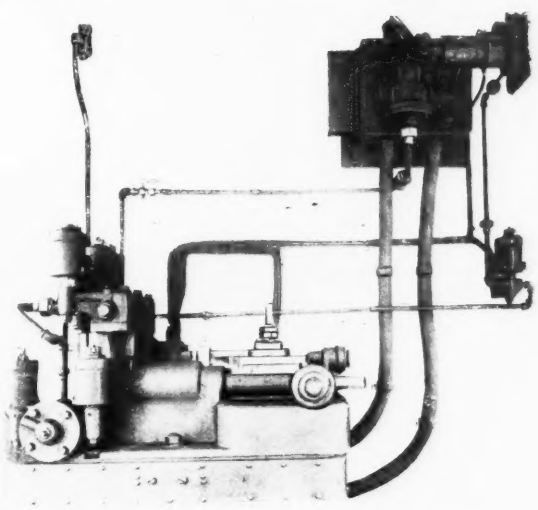


Fig. 1.—Westinghouse Electro-Pneumatic Controller.

means secured by this simple substitution; the use of electricity permits of the adoption of certain methods of train operation whereby the railway proprietor can, with great benefit to himself, meet the requirements of the passenger.

The reason is that electricity is the most flexible and adaptable power agent known. The electric motor can be controlled from any point distant from the motor with the same certainty and ease as if the controlling gear were alongside the motor. Advantage has been taken of this property to sub-divide the propelling mechanism of a train; thus a train may have two or more locomotives in its length, each and all of which are controlled from the leading vehicle of the train. How this arrangement comes to meet the conditions required by suburban railways is easily understood. It has long been known that some such system of railway operation would possess great advantages; the difficulty up to within the past few years has been to obtain a commercially practicable and reliable means of applying the principle. The Westinghouse electro-pneumatic system of train control has been developed to serve this purpose, and wide practice on electric railways has proved it to be a complete success.

The following brief description of the apparatus used in connection with the Westinghouse system and of the main principles entering into the working of the system will be of interest, and will show how a difficult problem in railway engineering has been solved in a simple and most effective manner. The system can be used for any number of locomotives or motor cars per train. The motor cars are exactly similar in equipment, and any one may form the driver's car. The size and frequency of trains can thus be adjusted to suit exactly the requirements of the traffic. The electric power equipment of each motor car is exactly the same as that required in the usual hand-controlled single locomotive practice. Each motor car is fitted with motors, current collectors, main circuit breaker, controller, &c.; the apparatus required for the electro-pneumatic control of the train is additional and consists essentially of small compressed-air motors which take the place of the driver's hand, and actuate the controllers and circuit breakers. The apparatus, as fitted to the controller and circuit breaker, is shown clearly in fig. 1. The two vertical shafts of the controller are extended above the controller cover to receive the actuating gear which replaces the usual hand levers. The projecting end of the shaft of the main drum of the controller is fitted with two ratchet wheels and a pinion wheel. The former serve for moving the controller "on." The pawls are carried on the end of the piston rod of a small pneumatic motor, which always gives a short complete stroke, moving the controller drum definitely, step by step, to the operating position required. The drum is prevented from moving, by momentum, past the required definite position of each operating point by a suitable mechanical device engaging a series of stops on the ratchet wheel.

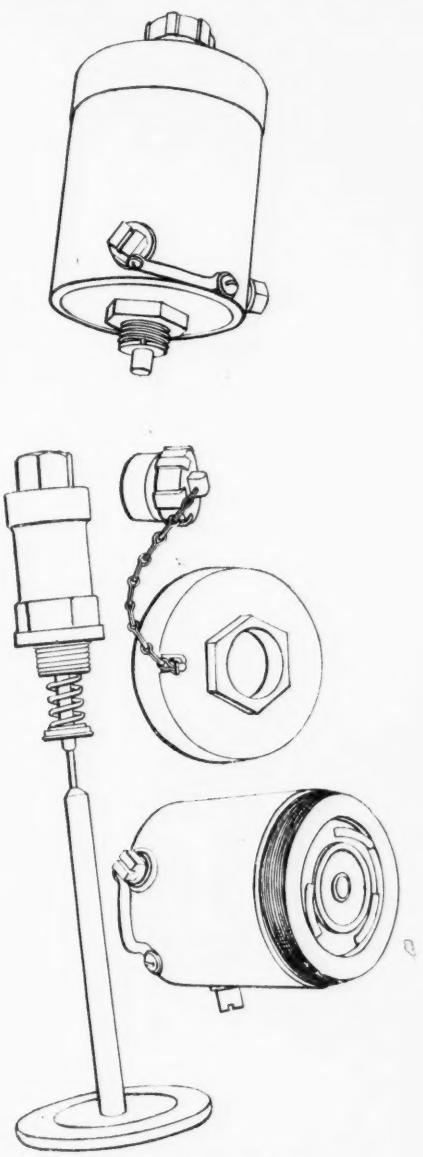


Fig. 2.—Electro-Magnetic Pin-Valve

In returning the controller to "off" position the pinion on the shaft is brought into use. This gears with a rack carried on the piston rod of a long stroke pneumatic cylinder, which also always makes a definite complete motion to the end of its stroke when it is put into action. Thus, no matter in what operating position the controller drum may happen to be, the return to the "off" position is always complete; the controller drum cannot be returned partially towards the "off" position. The reversing drum of the controller is also actuated by a rack-and-pinion gear. A pinion on the shaft extension is geared with a rack carried on the centre of a rod, at each end of which is the piston of a small pneumatic motor. The effect of putting either of these motors into operation is to throw the reversing drum of the controller completely over to one operating position or the other, according to the train-running direction required. The circuit-breaker is also actuated by two small pneumatic motors, one for each position of the switch, "closed" and open.

The admission of compressed air to all these small motors is accomplished by small electro-magnetic pin-valves, the form and construction of which are shown in fig. 2. The magnets are of the ironclad type. The coil surrounds the inner core, which forms one pole, the cylindrical enclosing shell forming the other pole.

The magnet circuit is closed at the lower end, and the disc armature is at the other end. The action of the magnet and the valve is clearly conveyed by the illustration. On closing the electric circuit of the magnet this disc is attracted downwards, compressing the

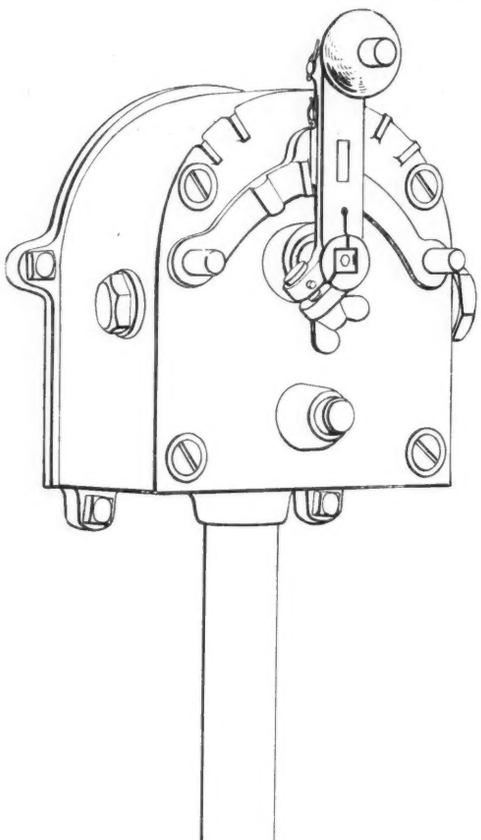


Fig. 3.—Multiple-Control Switch: Exterior.

spring washer and the valve spring, opening the valve and admitting compressed air behind the motor piston. When the magnet circuit is opened, the springs rise and close the air valve.

The current required to operate each valve is very small—0·05 ampere at a pressure of about 7 volts. A small secondary battery provides the current; one charge of these cells lasts for a considerable time, and they are recharged without any inconvenience whilst the car is in service.

Every motor car is fitted with a multiple-control switch, working in the low pressure battery circuit. By means of any one of these switches the driver controls the whole of the motor car apparatus in the train. The general construction of the multiple-control switch is shown in figs. 3 and 4. The switch handle is detachable, and current is only connected to the switch when the handle is in position. Moving the switch handle over to the right or to the left causes the train to move in either one direction or the other. The first motion of the switch in either direction sends current through the corresponding valve magnets of the reversing gear of all the controllers, thus throwing their reversing drums to the positions corresponding to the required train direction.

The switch handle may be turned straight over to its limit corresponding to the full parallel running of the train motors, or the handle may be turned only part of the way; in either case the handle is turned beyond a certain neutral point or "lap" position. Although the switch handle can be turned quickly and straight to any running position, the car controllers are not moved over simultaneously with the switch handle, in which case considerable stresses would be thrown on the motors. The gear of each controller works in conjunction with an automatic repeating device, and the controller drum is turned methodically step by step by the repeated backward and forward strokes of the short air-motor working the pawls on the ratchets. The repeating device ensures the repeated action of the air-motor until the controller drum assumes the operating position corresponding to the position of the handle of the driver's multiple-control switch. The driver can, however, arrest the motion of the controller drums, and consequently the speed of the train, before they have reached the position corresponding to the position of the switch handle, by returning the switch handle to the "lap" position, which has the effect of stopping the action of the operating motors of the controllers and causes the main drums to maintain their present position.

The motions of all the controllers in a train are in perfect synchronism, so that they always rest or move together. It has already been mentioned that the step-by-step movement of the controllers tends to preserve the motors from sudden damaging overloads; they are further protected by an automatic device which arrests the motion of the controllers, should their current reach a certain high pre-determined value. A reduction of the current releases this locking and allows the controllers to continue their advance to the required operating position. Returning the multiple-control switch beyond the "lap" position causes the controllers to return at once to the "off" position.

The compressed air supply for the controller and circuit-breaker operating gears is drawn from the brake reservoir beneath each motor car. These reservoirs are kept constantly charged by an electrically-driven compressor. It will be seen that the use of a common compressed air source for both the train braking and controlling gear is one which is eminently adapted for automatic interconnections, whereby the greatest safety in train operation is secured.

In connection with the Westinghouse electro-pneumatic sytsem there are one or two ingenious and effective emergency devices worthy of particular attention.

The connection between the air-brake operating cylinder and the releasing cylinder of the controller ensures the instant return of the controller to the "off" position, should the train brakes be applied when the motors are receiving current. It is well known that a break in the continuity of the pneumatic system of a train equipped with Westinghouse automatic brakes, caused either by a parting of the train or by any other accident, result at once in the brakes being applied over the whole train length. Such a failure or accident would, in a train fitted with the Westinghouse electro-pneumatic system of control, result in the instant cutting off of the driving current.

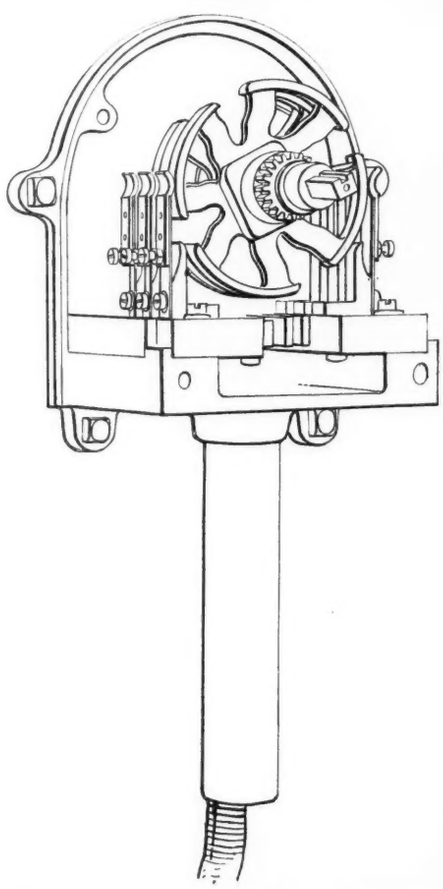


Fig. 4.—Multiple Control Switch: Interior.

An interconnection between the controller main shaft and the valve circuits of the controller reversing gear makes it impossible either to reverse the controller or close the main circuit-breaker when the controller main drum is in any operating position. The controller reversing gear and the closing cylinder of the circuit-breaker are so inter-connected that the latter cannot be closed unless the reversing drum of the controller is actually in the

definite position necessary for the required direction of train running. The circuit-breaker and the operating gear of the controller main drum are inter-connected so that the controller is thrown at once to the "off" position should the circuit-breaker open automatically either from overload or any other cause.

Many important advantages attend the use of the Westinghouse electro-pneumatic system. The apparatus is exceedingly simple and reliable, and no expert supervision is required, no part of the gear being too intricate or delicate for the ordinary mechanic. The two agents—electricity and compressed air—are admirably adapted for the work of controlling simultaneously several motor-cars in one train. Electricity is the most rapid means of communication between the driver and the various motor-cars. Compressed air motors are the best and simplest for giving the definite straight line motions required by the controllers and circuit breakers. The electrical controlling circuit throughout is independent of the main electrical power supply, and is of such low pressure that risks of leakages or faults are a minimum, and no possibility of shock to employés exist.

A supply of compressed air is required in any case for efficient train-braking. When this supply can be used with such advantage for the train controlling gear, and at the same time permit the use of such devices as shall make railway travelling safer than ever, nothing further by way of comment is necessary.

The coupling of train vehicles is effected very rapidly, and occupies no more time than if the train were drawn by a single locomotive, and simply had the couplings and the brake-pipes to join up. As a matter of fact, an automatic coupling has been designed by Westinghouse engineers for use in conjunction with the electro-pneumatic system of control whereby the electrical, compressed air, and draw-bar couplings are made simultaneously in the shortest possible time.

Safety, speed and economy are the three most important elements required for successful railway working. The question of safety has already been dealt with to a certain extent. The greatest possible speed and economy are gained by distributing the driving power over the train length. The rapid acceleration obtainable with lighter trains and distributed driving wheels, the absence of slip, and the rapidity of braking, are all points which conduce to greater speed and economy in driving power. The starting strains are divided and distributed, and the life of couplings and rolling stock is lengthened. The hammering at rail joints, the effective train weight on bridges and elevated structures, and vibration are reduced to a minimum, and wear and tear of the track and rolling stock are, therefore, as low as possible. Trains are easily formed and split up into lengths most suitable for the traffic to be dealt with and the power required for each train is most economically applied.

The question as to how many motor cars per train ought to be used in ordinary service has been frequently discussed. The outcome has shown that opinions favour the use of two or three motor cars for each train, depending on the traffic and operating conditions. The advantages just mentioned are all gained to a very considerable extent, while the use of a great number of motor cars per train possesses drawbacks mainly on account of expense, both of first cost and of maintenance, without a proportionate increase in other advantages.

The Westinghouse electro-pneumatic control system has been in use on several lines for some years past. On the Elevated Railways of Brooklyn, U.S.A., extended competitive trials of several multiple control systems were carried out, amongst which was the Westinghouse system. The outcome of these trials was the placing of a very large order covering the complete equipment of the rolling stock of the railways with the Westinghouse electro-pneumatic system. The traffic of the Mersey Tunnel Railway, now being converted for electric traction, is to be operated entirely with the Westinghouse system of electric train control.

THE ELECTRIC LIFTS ON THE CITY AND SOUTH LONDON RAILWAY.

A few weeks ago we recorded with considerable satisfaction tha the lifts for the G.N. & City Railway Co. were to be supplied by British firm—Messrs. Easton & Co., Limited. We are now able to give details of work of a similar nature, which they have carried out at the stations of the City and South London Railway Co. Hydraulic lifts are still in service at some places on the line, but Easton's electric lifts are installed as follows:—

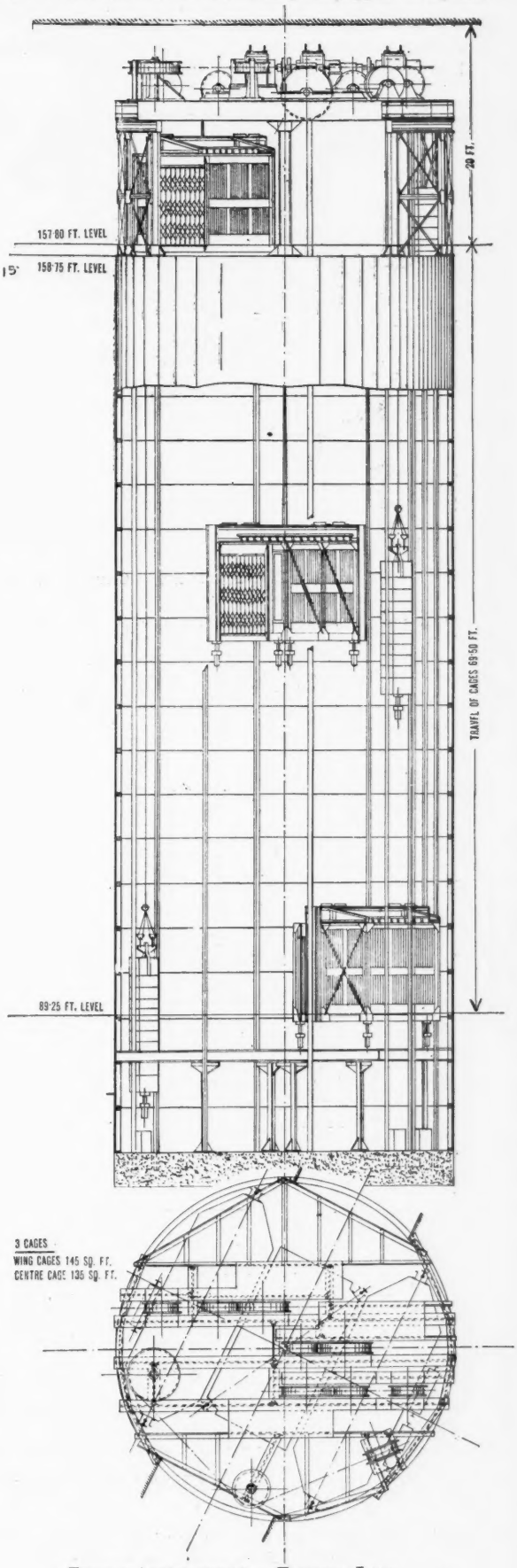
Two at Clapham Common, two at Clapham Road, one at Kennington, two at London Bridge, two at London Bridge Joint Subway near the Brighton & S.C.'s Railway station, five at the Bank station, four at Moorgate Street, three at Old Street, two at City Road, and three at the Angel station.

The capacities of the lifts range from 55 people to 100 people.

In the next column we show a typical arrangement of the lifts as installed. The lifts in connection with the Moorgate Street and Clapham Extensions have their driving gears arranged at the bottom, whilst those for the Islington Extension and the London Bridge Joint Subway have them at the top.

The ordinary working speed will be 180 ft. per minute for all lifts. The cages and balance weights are guided by means of rails attached to the shaft linings, and are directly connected by eight flexible steel ropes, passing up from the top of the cages over a patent system of driving pulleys, then over guide pulleys, down to the balance weights. Buffers are fixed underneath the cages and balance weights, to stop them without shock should they over-run the regular stopping places.

The balance weight is made up of a number of cast-iron pieces held together by long bolts, and fitted with guide slippers at top and



Typical Arrangement of Electric Lifts.

bottom. The total weight is equal to the weight of the cage plus half the load.

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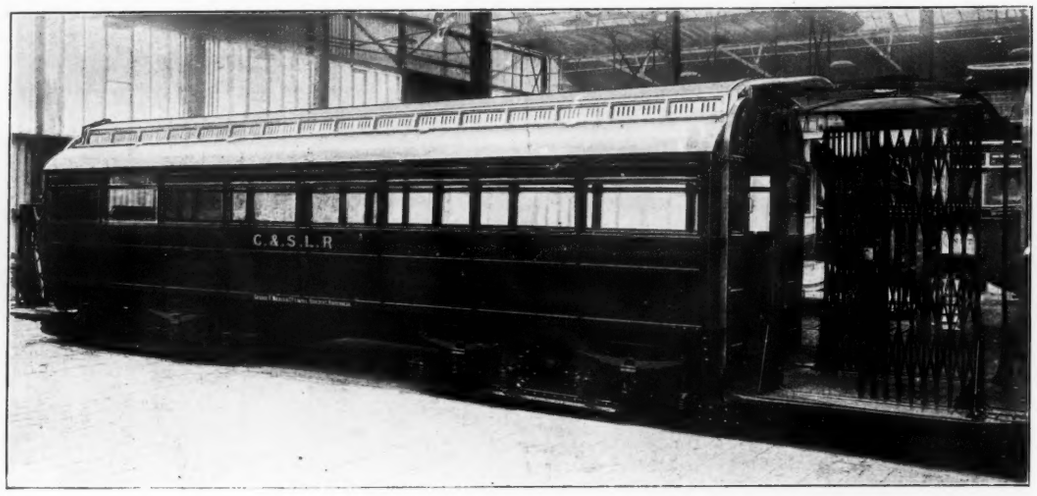
The buffers consist of cast-iron rams fixed to the cage and balance weight, working in cast-iron dash pots, which are supported on long bolts on which they can slide.

The overhead structure consists of rolled joist columns and riveted girders of mild steel, placed direct on the top flange of the lining of the shaft. The columns are braced together where possible, and tied together by cross girders on the top.

When the current is switched on to work the lifts, the magnets become excited and raise the weighted lever, so that the grip of the brake blocks is released; if the current is switched off or interrupted accidentally, the weighted lever again forces the brake-blocks against the brake pulley, and brings the lift quickly and smoothly to rest.

The ultimate strength of the eight ropes is not less than 24 times



New Train on the City and South London Railway. (Messrs. G. F. Milnes & Co.)

The hoisting gear consists of a patent arrangement of rope sheaves driven by means of worm gearing. The latter consists of a case-hardened mild steel worm forged on the shaft, gearing with a steel worm wheel having a phosphor-bronze rim.

The worm and wheel are enclosed in a cast-iron casing forming an oil bath, thus ensuring continuous lubrication. The worm is placed above the wheel, so that any adjustments may be carried out with a minimum of trouble. The worm gear is supported on a massive bedplate extended to carry the motor and automatic brake.

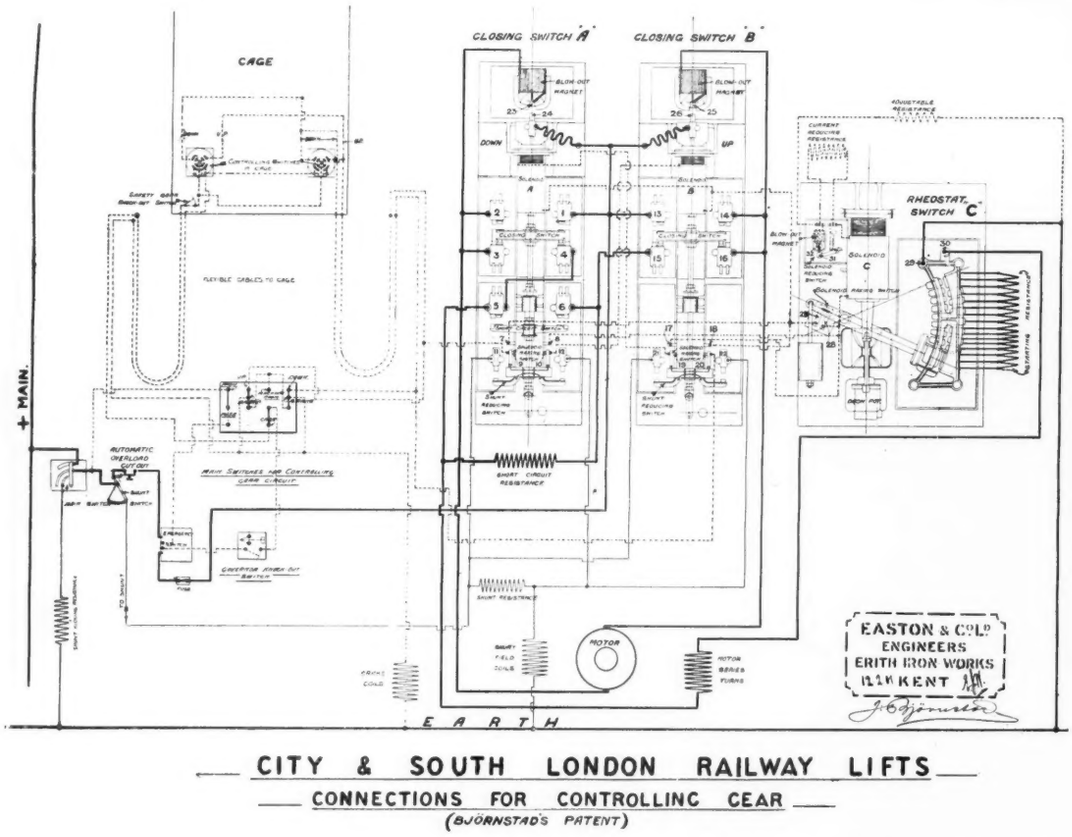
The brake is of the magnetic type, and is arranged so that when the current is off and the magnets not excited, a weighted lever forces the brake blocks against the brake pulley, which forms part of the coupling between the motor and worm shafts.

the working load. The ropes are connected to the cages by a special device, which obviates the necessity for sharp bends in the ropes.

The guides are supported from the lining of the shaft by strong brackets made of mild steel plates and angles.

The cages are as large as can be conveniently got into the available space, and are 8 ft. high. A seat is placed along one side in each cage. An emergency door is fitted in each cage, to enable passengers to be transferred from one cage to another in case a lift should stop accidentally between the landings, and each cage has two entrances.

The suspension frame is of Siemens-Martin steel, and consists of strong top and bottom frames connected with stiff bracing round the sides of the cage.



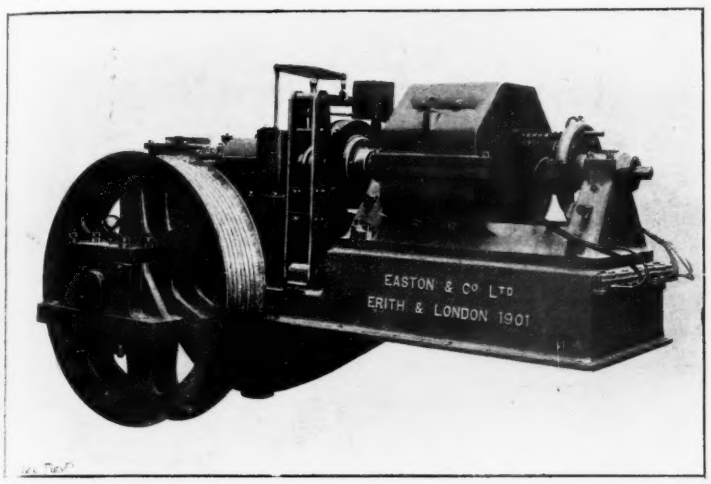
CITY & SOUTH LONDON RAILWAY LIFTS

CONNECTIONS FOR CONTROLLING GEAR

(BJÖRNSTAD'S PATENT)

Long iron slipper guides running on the fixed guides in the shaft are supported by the iron framing, in such a manner that any side pressure between the slipper guides and the framing is transmitted through springs, to prevent shocks being transmitted to the cage.

The framework of the cages for the lifts at Old Street is shown on page 980. The safety gear underneath the cage is normally set with



Electric Lifts: Arrangement of Driving Gear, &c.

e springs compressed and in position, ready to act when a strain is rown upon the small rope from the lever on the side. The illus- ation shows the position of the safety gear after it has acted, that , with the springs extended and the toggle levers in the middle oved downwards. The tee handle shown above the levers is the pparatus for re-setting the safety gear from the inside of the cage fter it has acted.

The safety gear consists mainly of two cast-steel cams acting as pair of powerful tongs, with steel jaws arranged to grip the steel uides. When the springs are released and allowed to extend, they ause a tension of the horizontal rod going through the centre of the prings, and this again pulls two eccentric-shaped cams between the ong ends of the levers so as to force them apart and thus cause ressure on the guides between the short ends of the levers. The springs re very powerful, and the pressure brought to bear on the guides is ufficient to sustain the whole weight of the cage and the full load in- ide it. The oil buffers below the cage are also shown on the next page.

The safety gear is fitted to the underside of the cage, and is designed to come into action in case the speed of the cage should exceed the normal. Under normal conditions the gear is locked by a small catch, which, when p lled out, releases the springs which work the cams.

A small flexible steel rope connected to this catch passes over a governor pulley at the top, and then down to the balance weight; the governor is set to act when the speed reaches the maximum limit of 200 ft. per minute, when it grips the rope and causes a strain in it sufficient to pull out the catch of the safety gear and thereby bring the cage to rest.

In addition to this governor actuating the safety gear, there is also another centrifugal governor which is set to act before the one described above, and when the speed at which this is set to work is attained, the governor releases a small switch in the controlling gear circuit, at once stops the motor and applies the brake. When the safety gear comes into action it actuates, in addition to the cams of the safety gear, a switch in the controlling gear circuit, which immediately stops the motor and applies the brake. The arrangement of the driving gear and driving pulley, motor, and magnetic brake is illustrated in the illustration shown above, while the figure in the next column shows the switch panels of Björnstad's patent controlling gear, and also an exterior and interior view of one of the operating switches in the cages.

The motor is of the 4/P ironclad partially enclosed type, and is wound "starting compound," *i.e.*, shunt wound with a few series turns, so that the field is strengthened when the current increases.

The field coils are wound on removable brass formers. The upper half of the field body can be lifted off with the magnet coils, thus allowing the easy removal of the armature, and giving access to every part of the machine. The armatures are of the slotted drum type. The core is built up of annealed charcoal iron discs on the shaft, which is forged in the shape of a spider, where it supports the discs. Half-round grooves are formed in the spider arms and corresponding half-round notches in the discs, and through these are passed tight fitting bolts, which clamp the discs together when screwed up, and also act as efficient driving keys. The shafts are of mild steel, and the bearings are lined with white metal, with automatic ring lubrication. The commutators are made of hard drawn copper, insulated with the best mica, and the sections are made so deep, that after 1 in. radially has been turned off, they are still able to carry the full current without undue heating. They run sparklessly at all loads, and in both directions, without shifting the brushes; the latter are of carbon.

The details of the electrical connections for the switch gear are given on page 978. We understand that this gear has proved itself fully efficient, and admirably suited for the heavy work which it has to perform, and the wear and tear of the contacts and other working parts are reduced to a minimum.

The average efficiency of the complete lift, that is, the ratio of work done in raising the unbalanced load to input at motor terminals, we understand to be about 50 per cent.

The electric controlling gear is arranged in accordance with Mr. J. Björnstad's (Messrs. Easton & Co.'s manager and chief engineer) patent system, and consists of three sets of main switches, each worked by a solenoid or long-stroke magnet.

One set of these switches closes the motor circuit for the "down" journey: another closes the circuit for the "up" journey, whilst the third cuts out the resistance in the armature circuit.

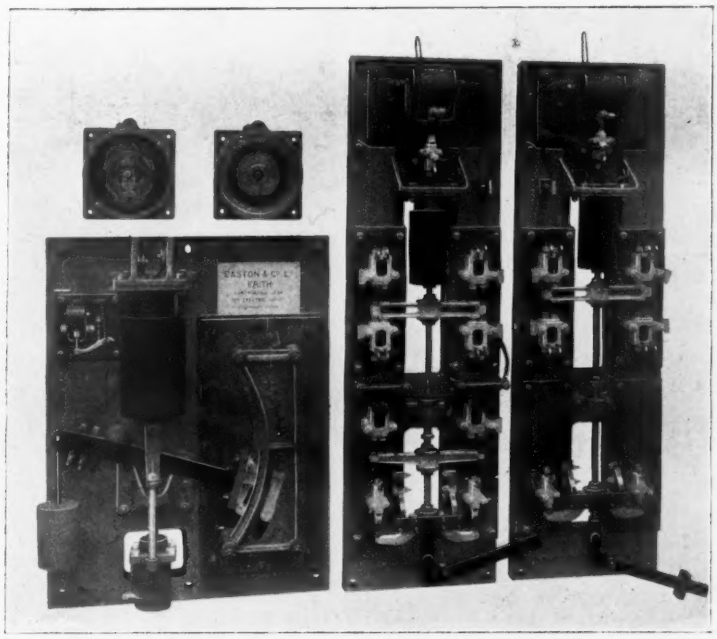
The solenoids of the closing switches are allowed to act as quickly as possible, but the solenoid of the rheostat switch is fitted with an adjustable dash-pot, so that the speed at which the resistance is cut out is constant, and is not under the control of the attendant in the car.

The magnetic brake is arranged to be actuated direct from the switch in the car, so that the brake can be worked independently of the motor. All the principal contacts have carbon breaks, and magnetic blow-outs are fitted to the contacts where arcing takes place.

The controlling switches in the cage are arranged to act as limit switches, as the switch arms are brought back into the mid-position by levers fitted to the back of the switches striking against blocks fixed in the lift shaft at the top and bottom levels.

New Trains on the City and South London Railway.

We illustrate on page 978 one of the new coaches which has been supplied by Messrs. G. F. Milnes & Company, Limited, of Hadley and Birkenhead, for this underground railway in connection with the recently-opened extension to Islington. These coaches are made up into trains of four, movable platforms being arranged between the coaches, and pivotted to allow of freedom in passing round curves. The platforms are fitted with patent collapsible gates, which are always kept closed when the train is in motion. The coaches are



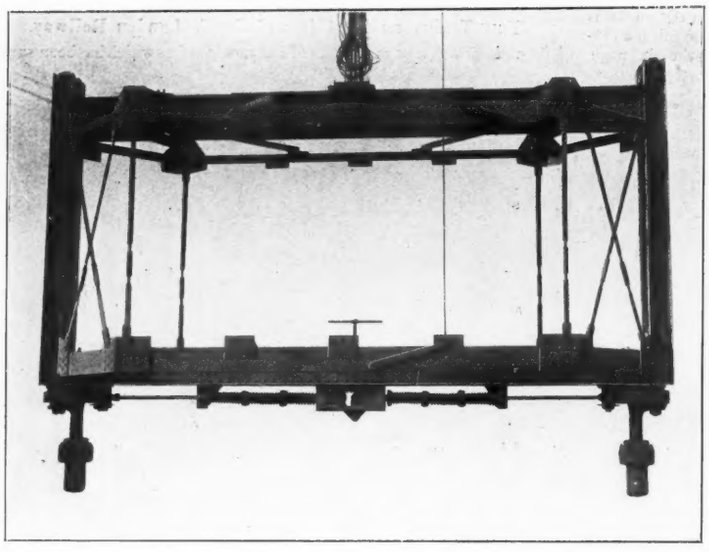
Electric Lifts: Switch Panels and Operating Switches.

designed so as to secure the maximum amount of room consistent with the small diameter of the subway through which they have to run. They are built almost exclusively of teak, handsomely fitted up and finished, and, of course, lighted throughout by electricity, with the exception of the tail lights, which are arranged to burn oil. Electric bells are also installed. The sides of the body are shaped to the form of the circular tube, and the steel frame is recessed in the centre, so as to get as near as possible to the rail level, and so gain headroom. The teak sole bars are plated with steel on both sides the whole length. The interior of the coach is handsomely panelled in figured wainscot oak, with ceiling of Lincrusta Walton. The seats and backs are arranged longitudinally. Both the seats and backs are highly finished, and upholstered in figured repp. Each coach has seating accommodation for 34 passengers. The coaches are mounted upon bogies of the most improved type, with springs arranged so as to ensure the coaches riding easily, and they are fitted with Westinghouse automatic air brakes. Double sliding doors are fitted at each end, and in the centre a framed partition is arranged, dividing the coach into two parts. The length of each coach over the corner pillars is 26 ft.

THE TRAMWAYS AND LIGHT RAILWAYS EXHIBITION.

There was held at the Agricultural Hall in June and July last year, as readers of the Electrical Review were made fully aware at the time, the first English exhibition of tramway and light railway apparatus. This exhibition was arranged under the patronage of the Tramways and Light Railways Association, the lord mayors and mayors of the principal cities of the United Kingdom, the chairmen of municipal tramway committees, and the leading tramway companies.

The exhibits comprised every kind of apparatus for the equipment of tramways and light railways with mechanical traction, and cars were shown in actual operation. The exhibition was daily visited by official deputations from the councils of all the principal cities and towns of the United Kingdom. The importance of the information thus obtained was felt to be very great, and the municipal representatives repeatedly expressed their indebtedness to the exhibition for valuable assistance in the work of tramway and light railway equipment, with which many of them are now occupied. The development of facilities for local communication was greatly advanced by the exhibition.



Electric Lifts: Framework of Cage.

The wish has been expressed both by representatives of local authorities and by manufacturers, that the exhibition should be repeated, and it has been decided that a second exhibition shall be held in 1902; the date has been fixed for July 1st to 12th. This date has been chosen at the request of the "Union Internationale Permanente de Tramways," an influential Continental association comprising a membership of about 500 engineers, tramway managers, and directors, which, on the invitation of the Tramways and Light Railways Association, will hold its biennial Congress in London from July 1st to 4th. The invitation to meet in London was accepted on the condition that the Tramways and Light Railways Exhibition should be repeated, in order that the members of the Union might have the advantage of inspecting a comprehensive collection of apparatus such as that shown at the first exhibition.

The forthcoming exhibition is being promoted by the *Tramway and Railway World*, and the following gentlemen have consented to act as an Advisory Committee:—

Alfred Baker, Esq., manager, London County Council Tramways.
C. Reville Bellamy, Esq., M.I.C.E., general manager, Liverpool Corporation Tramways.
G. C. Cuningham, Esq., M.I.C.E., general manager, Central London Railway.
A. L. C. Fell, Esq., M.I.C.E., M.I.M.E., general manager, Sheffield Corporation Tramways.
C. W. Gordon, Esq., manager, Dublin United Tramways Company.
E. George Mawbey, Esq., M.I.C.E., borough engineer, Leicester Corporation Tramways.
J. M McElroy, Esq., general manager, Manchester Corporation Tramways.
Andrew Nance, Esq., manager, Belfast Street Tramways Company.
J. Erskine Pitcairn, Esq., general manager, Edinburgh and District Tramways Company, Limited.
Wm. Wharam, Esq., general manager, Leeds City Tramways.
John Young, Esq., general manager, Glasgow Corporation Tramways.

The London County Council and our large provincial towns have to some extent recognised the needs of the people in the direction of electric traction, but it is not too much to say that the action taken in many instances has been half-hearted; confidence in the methods of mechanical traction has been lacking, and public opinion but partially convinced. A large and comprehensive exhibition, the Committee is convinced, will serve effectively to inform the public as to what has been done in the field of light railway and tramway enterprise, and thus to create confidence and courage, among both municipal authorities and private parties to take up the work in a bolder and more determined spirit.

The leading manufacturers have already expressed their intention to assist in the project, by making most interesting exhibits, and over one hundred firms have been allotted sections, which cover the whole of the ground floor, and a portion of the galleries.

Inquiries in regard to space and other matters may be addressed to the Secretary, Amberley House, Norfolk Street, London, W.C.

Car Fenders in the States.—The tramcar fender sometimes does good work in our provincial cities where trolley lines are in operation, although it has been responsible for injury to life in some cases. In the States it seems that the efficient fender is of real value, but indifferent forms do more harm than good. We read in an exchange as follows:—"The fenderless car and the car equipped with the home-made fender continue to get in their deadly work. A boy nine years old was decapitated by a street car, which was equipped with a home-made fender, in Brooklyn the other day. The same day, in Jersey city, a six-year-old boy was decapitated by a fenderless car. Sometimes city officials are powerless to correct these evils owing to defective charters. When such is not the case, however, the mayor and council should use all diligence in the passage of an ordinance compelling the use on all street cars within the city limits of a well-made fender."

Tram's Cars.—The following letter appeared in the *Pall Mall Gazette* of December 3rd. Tramway managers are, of course, always open to consider criticisms which give pointers as to the improvement of tramway service:—

"Monsieur Le Redacteur,—Permit me to approach you on a subject which is near of my heart. I am stranger, and I inhabit for some time one of the charming *faubourgs* of your vast metropolis.

"I travel each day to the City, and once more back again, because I am merchant and make some affairs at London. I voyage in tram's cars and in train. At the regard of the previous I would tell somethings which have to me risen at the head.

"Some tram's cars are constructed to convey 30 peoples inside them—it is to say 15 of the two sides.

"Why then, Mister, should the *conducteurs* be permitted to cry 'Outside only!' if sometime only 14 have seated themselves of each side?

"I perceive, also, that gentlemen must not smoke inside of the cars. Should they therefore not be forbidden of carrying the lighted cigar at the hand?

"In some cars there hangs of the rails over the heads a number of glands, or tassels, and these glands will be, at the occasion, very irritating to the top hat.

"Surely, Monsieur, it is not essential to have glands hanging of the rails?

"The top hat is a smooth creation which bears not well that one should irritate it, and his owner must swear at himself when he discovers the irritation on it. Glands are, therefore, immoral.

"To end, I would gently ask the management to affix an advice on some public place at all times when it is decided to interrupt the regular service of tram's cars in favour of processions, of sort that the intending passagers can voyage of another manner in processional hours if they have envy.

"Agree, Mister the Redactor, the expression of my sentiments the most sincere,

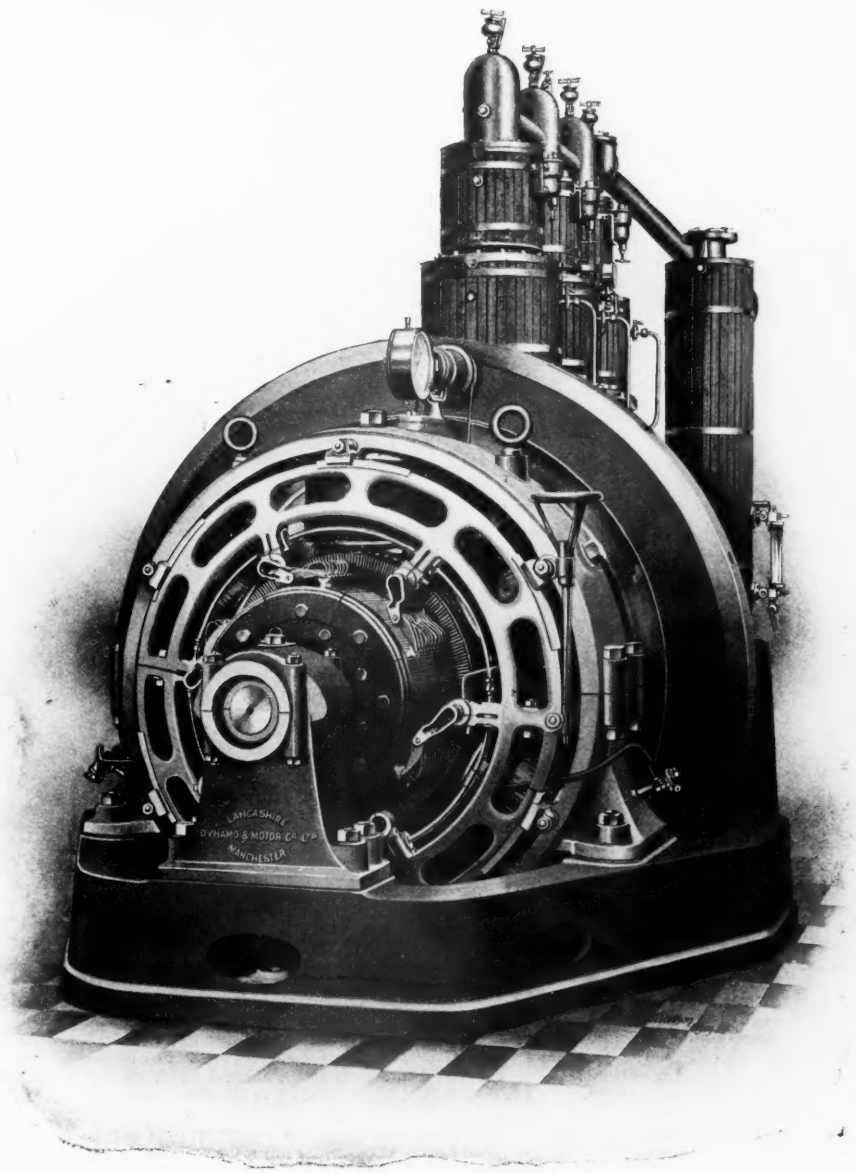
November 30th. "Victor Outre mer."

Machinery and Equipment for Electric Traction Systems.

Plant our Manufacturers are now Supplying.

Willans-Lancashire Steam Sets for Tramway Power Stations.

A standard traction generator, as made by the Lancashire Dynamo and Motor Company, Limited, of Trafford Park, Manchester, is shown below, coupled to a Willans engine (3 H. S.). Generators of this type have recently been supplied for traction and lighting to the municipal authorities of Wrexham, Rhyl, Lowestoft and Farnworth, and are at present on order for Accrington, Motherwell, Gravesend, Wallasey and Long Eaton Corporations.



Willans-Lancashire Traction Generator.

The machine shown is a 150-kw. six-pole machine, but embodies all the characteristics of the makers' larger six-pole and eight-pole combined traction and lighting generators. The magnets are of steel, elliptical in section, and securely bolted to the yokes, which are split on the horizontal diameter. The yokes are provided with brackets lined with white metal to support the brush ring. The shunt field coils are former wound, each coil being provided with its own terminals. The series field coils are made of bare copper strip wound on edge. Great attention is paid to the insulation between the field windings and the magnets, so that in the case of accidental interruption of the shunt circuit there is no danger of the field winding earthing.

The bearings are of the spherical seated, self-oiling type, of liberal dimensions, each having two brass oil rings which dip into the well below. The armature is built upon a cast-iron sleeve which extends to the bearing on one side, and is formed into a coupling on the other, thus enormously strengthening the shaft, and eliminating the strain on keys and shaft incidental to changes of load, a particularly important point in traction work. The commutator is also carried on this sleeve, and consists of hard drawn copper bars of liberal depth built up under hydraulic pressure, and insulated with specially selected mica. The end rings are divided

into segments which are drawn together by special steel rings of wedge-shaped section. In this way the bars are held down with great pressure, but are left free to expand longitudinally. The brush holders are the Lancashire Dynamo and Motor Company's patent type, made of light brass stampings, so that the inertia is small. They are pressed against the commutator by means of springs giving a long range of pressure, the same springs serving to hold them off the commutator when they are drawn back.

The brushes are of carbon, and the current density does not exceed 30 amperes per sq. in. The brush holders are carried by a special carrier which supports both ends of the steel spindle. These carriers being clamped in the arms of a brush ring supported from the magnet yokes, the brushes are not subjected to vibration, and interference with the ready removal of the bearing caps is avoided.

We understand that all the company's generators are designed to stand heavy overloads, and will carry 50 per cent. overload for a quarter of an hour, and 20 per cent. for two hours, without undue heating or sparking. Special attention is paid to the accurate balancing of armatures. The maximum temperature rise on full load does not exceed 70° F. The Lancashire Dynamo and Motor Company's standard protected-type motors are particularly well adapted for coupling together to form boosting and balancing combinations of very compact and neat appearance.

Car Lifting Jacks.

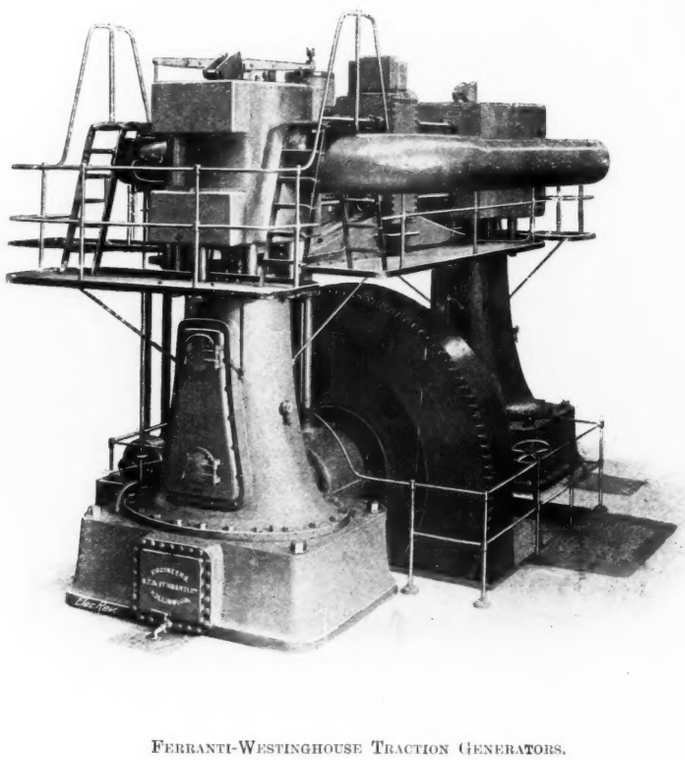
Mr. C. R. Heap, of 47, Victoria Street, S.W., is the representative over here for the Barrett lifting jacks, which are manufactured by the Duff Manufacturing Company, of Allegheny, Pa. This jack is claimed to be positive and quick in action, and to have simple and easy movements, and the materials used in its construction are of the strongest and best. The Barrett jacks are all made up with malleable iron frame, steel pawls, bearings and pivots of machinery steel, and forged steel rack; the wearing parts are removable, and readily renewable at slight expense. The large rectangular-shaped base is one of the main points of these jacks; this kind of base gives great lifting strength, and yet fits into close quarters not get-at-able by round or bulky stands. The ribs on the jack frame combine strength with light weight, and handles are provided for carrying the machines. All of the jacks bear their loads either on the upper end of the bar, or on the foot near the base; they are thus adapted for either high or low set loads. The automatic lowering jack shown in the illustration is for car repairing and working, and we understand that it is fast taking the place of hydraulic jacks, for lightly loaded and empty cars, &c. It is claimed to be more portable, more easily applied, and less liable to derangement. It has a forged steel raising rack for reaching under car beds and lifting the same above obstruction. By means of its side lug, it can grapple low set loads with equal facility; it lifts and lowers on the downward stroke of the lever only, and the direction can be quickly reversed at will. The height when the rack is down is 28 in.; rise of lifting rack, 17½ in.; size of forged steel rack, 2 × 1¾ in.; weight, 90 lbs.; and the capacity, 15 tons. The trip jack has a capacity of 10 tons, and weighs only 60 lbs.; the bar rises 13½ in. The leverage is compound double acting, lifting the load on both upward and downward strokes of lever; the load can be instantaneously tripped from any elevation, as the operator pleases. The Barrett automatic lowering and trip jack is a combination of the features of all the other jacks in one. It can lift loads, lower loads, reverse direction of motion and trip or drop loads from any elevation in its range. Technically it is a compound lever, double acting, reversible tripping jack, with a capacity of 10 tons, and a weight of 67 lbs.

Car Lifting Jacks.

Ferranti-Westinghouse Generators for Manchester Tramways.

Among the latest plant installed at the Manchester Corporation electricity works, there are two steam engines, each driving a 750-kw. Westinghouse compound wound generator, designed to run either on traction or lighting circuits at a speed of 160 revs. per min. The engines are of the Ferranti vertical cross-compound type, having one H.P. and one L.P. cylinder, and were made by Messrs. Ferranti, Limited, Hollinwood. The diameter of the H.P. cylinder is 27 in., of the L.P., 51 in., and the stroke is 21 in. The reason for the low piston speed, is that the engines were designed to run at a considerably higher speed, and have been reduced in speed and output to suit purchasers. According to Messrs. Ferranti's usual practice, the crankshaft has only two bearings, and these being spherically seated in the bedplates, it is impossible for them to get out of alignment due to foundation settlement, unequal wear, or anything of that nature which might occur. This greatly reduces the risk of hot bearings.

In addition, all the main parts of the engines are lubricated by oil under pressure, supplied by valveless oil pumps driven from the crankshaft. This lubrication is most complete, in fact, practically speaking, the only attention required from the engine-driver is for the sight-feed lubricators to the cylinders. The engines are fitted with automatic expansion gear, the speed of the engines being controlled by a high speed spring-loaded governor which actuates a small valve controlling the supply of oil under pressure to a relay cylinder; this relay cylinder alters the point of cut-off in the cylinders. In addition, the engines are fitted with emergency governors positively driven from the crankshaft. These governors come into action at a higher speed than the main governors, and control the engines through a balanced throttle valve. Each engine is fitted with an ejector condenser, by Messrs. Körting Bros., of London.



Ferranti-Westinghouse Traction Generators.

The arrangement of exhaust pipes, condensers, water pipes, &c., is rather neat. The main exhaust pipes coming down from the low-pressure cylinders make an easy bend to the condensers. On the underside of these bends there is an outlet with suitable valve to an atmospheric exhaust main. The condensing water is supplied from a large main below the two overhead steam mains. As, however, the storage tanks supplying water to this main are at the opposite end of the building, and there is a large amount of plant between the Ferranti engines and the storage tanks, centrifugal pumps driven by D.C. motors have been installed alongside the engines and deliver directly into this common water main. Each of these pumps is driven by a Westinghouse motor, and is

capable of delivering 66,000 gallons of water per hour. The steam ranges, as stated, are in duplicate and are connected through stop valves and mild steel pipes to a steel breeches plate on top of

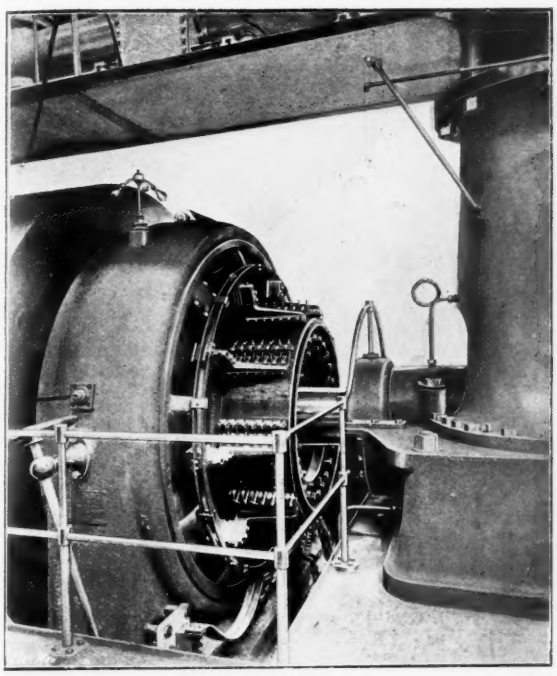


Fig. 2.—Westinghouse Traction Generator.

the separator, a single steel pipe being provided from the separator to the high pressure cylinder.

The whole forms a very complete and compact arrangement, and, in fact, as may be imagined from our photograph, makes a very handsome set. At the present time the whole of the tram service on the existing routes is being run by either one or the other of these two engines running alternate days, the engine not engaged on the traction load going on the lighting circuits during the afternoon when the heavy load comes on. Our smaller illustration (fig. 2) shows the Westinghouse machine, and demonstrates that though the dynamo is placed on the crankshaft between the cylinders, the commutator is very accessible.

Browett-Lindley Engines for Traction.

The engines manufactured by Messrs. Browett, Lindley & Co. (1899), Limited, of Patricroft, are familiar to, and highly esteemed by, electrical engineers; and the experience gained by the company in electric lighting, &c., has enabled them to take a front-rank position in electric traction. We illustrate one of the 1,250-I.H.P. engines made by Messrs. Browett, Lindley and Co. for the Salford Corporation, driving a traction generator made by Messrs. Mather and Platt, Limited, of Salford. The engines run at a speed of 100 revolutions per minute, with a steam pressure of 140 lbs. per sq. in., and a vacuum of 26 in., and are capable of withstanding an overload of 25 per cent. They are of the three-crank vertical tandem type, the high-pressure cylinders being carried on the top of the low-pressure cylinders, on polished steel pillars acting as distance pieces. The distance between the bottom covers of the high-pressure cylinders and the top covers of the low-pressure cylinders is sufficient so that the latter may be raised in order to renew the piston rings when required. Each low-pressure cylinder is carried on the top of a cast-iron distance piece containing the wiper gland, and the bored guides for the crosshead slippers. The frame is strongly ribbed, and is provided with hinged doors both at the front and at the back to give easy access to the working parts of the engine; each frame weighs about 14 tons.

The outer bearing next to the fly-wheel is 14 in. diameter by 2 ft. 8 in. long; the other three bearings are 13 in. diameter. The bearings are of gun-metal, lined with Dewrance's white metal. The crankshaft is of the built-up type; the crankpins are 13 in., and a 4-in. diameter hole is bored right through the shaft, and also through the crankpins. The ends of these holes are plugged up, and the holes act as the reservoir and conductor of the oil supply to the main bearings and crankpins.

The whole of the working parts of the engines work under forced lubrication, the oil being forced into each bearing by means of two simple valveless pumps.

The governor is of the high-speed centrifugal type; it is under forced lubrication throughout, and runs at a speed of 400 r.p.m.

The cylinders are 15 in. and 32 in. diameter × 30 in. stroke, and are fitted with loose liners. Both the cylinders and the cylinder covers are steam jacketed. The valves of the high-pressure cylinders are of the piston type; the low-pressure valves are of the balanced slide-valve type, and the clearances in the low-pressure cylinders are extremely fine.

The speed of the engines is controlled by means of the governor, acting on a throttle valve supplying steam to each high-pressure cylinder. The overload is obtained by an auxiliary throttle valve worked from the main governor, which admits high-pressure steam to the low-pressure cylinders when necessary. A knock-off gear is provided for high and low speeds, which, in case of need, disconnects the throttle valve from the governor, and allows it to drop on its seat, thus shutting the engine down immediately should any accident happen to the governor. The fly-wheel is 16 ft. diameter, and weighs 18 tons.

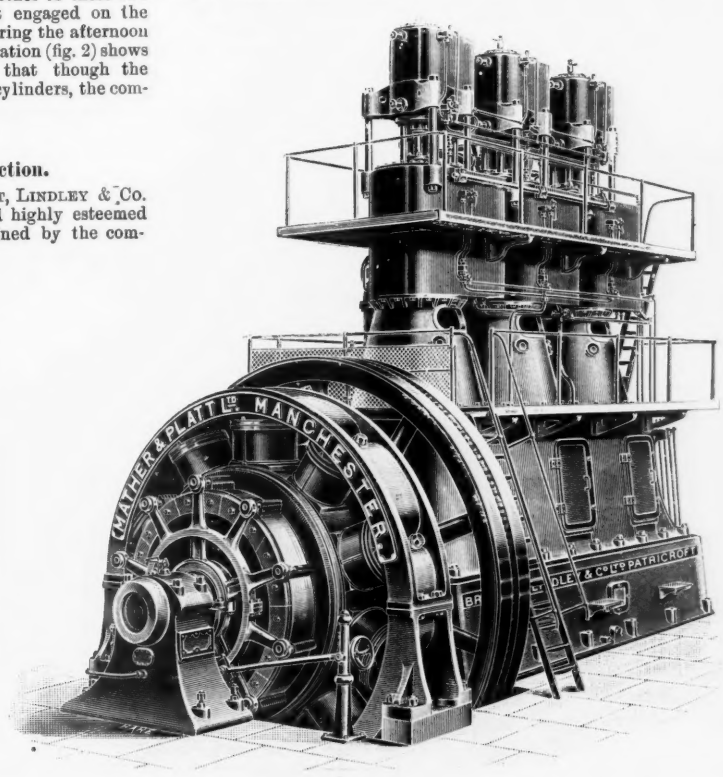
From tests made at Messrs. Browett, Lindley & Co.'s works, the drop in speed from no load to full load was 2½ revolutions; the temporary run up when all load was thrown off was 7 revolutions per minute.

The dynamos are of a very massive design. The yoke-ring is of cast-steel, and is made in halves. The pole-pieces are bolted to the ring with two bolts; the shoes are cast with the pole-pieces, and the spools for the field windings are slipped over the latter before they are bolted up.

The armature is of the drum type, with slotted core, built up on a double spider, which has one half-coupling cast with it, so that no stress passes through the shaft. The well insulated copper strip windings are entirely embedded in the slots of the core.

The normal output of the dynamo as compound is 775 kw. at 525 volts, for supplying power to the tramways, and as shunt 775 kw. at 480 volts for lighting; this normal working load can, however, be safely increased to 1,000 kw. should necessity arise. The dynamo has 10 poles, and the total weight is just over 50 tons, the armature alone weighing 25 tons. As a result of tests already made, the efficiency of the dynamo comes out as rather over 95 per cent. Of the 5 per cent. loss, hysteresis and eddy currents account for 2·27 per cent., C^2R losses for 2·57 per cent., and friction loss 0·16 per cent.

Messrs. Browett, Lindley & Co. have at their works a full equipment of apparatus for testing their engines on full load with full steam pressure before being sent out, and steam consumption tests can be carried out. The necessary electrical instruments and resistances for dynamo testing, and a surface condensing plant, are also installed.

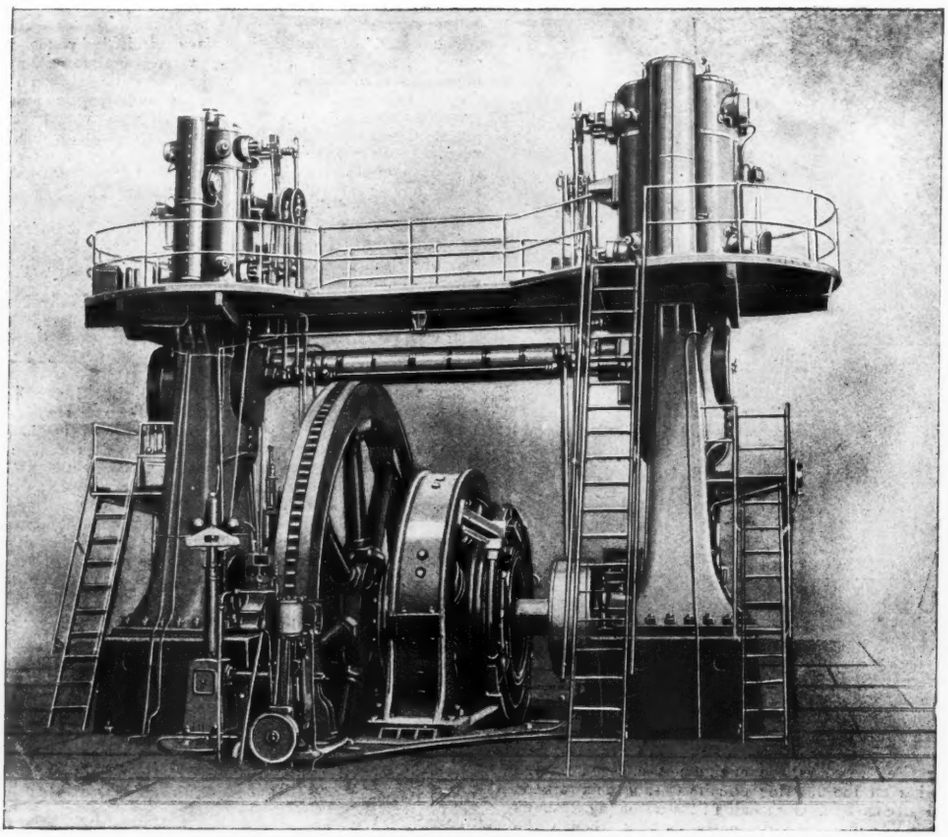


Browett-Lindley 1,250-I.H.P. Engine driving Mather & Platt Traction Generator.

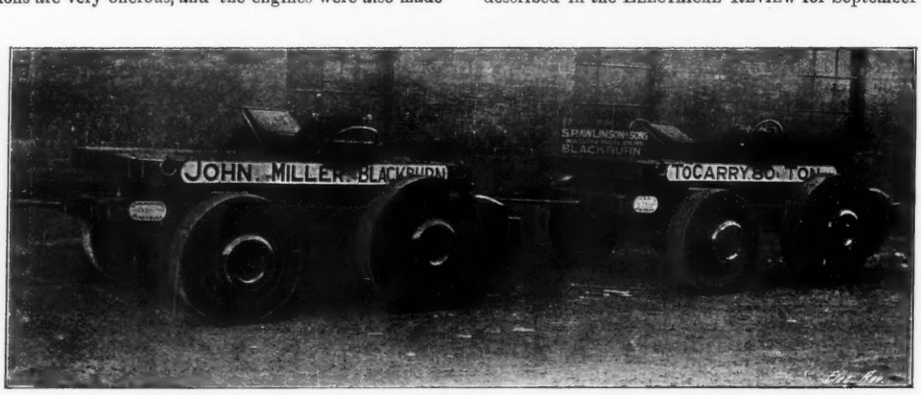
They have supplied, and have on order at the present time, high-speed engines for electric traction for Maybank, Merthyr Tydvil, Farnworth, Kirkcaldy, Beckenham, Swindon, Rochdale, Kingston-on-Hull, Middlesbro', Coatbridge, Australia, &c., most of which are of 500 to 800 H.P., besides engines for very many large electric light installations.

Engines for Sheffield Tramways Power Station.

The accompanying photographic illustration shows one of two engines installed about 18 months ago, at the Kelham Island Power Station of the Sheffield Corporation Tramway System, by Messrs. Cole, Marchent & Morley, Limited, of Prospect Foundry, Bradford. We understand that these two sets of engines have been in successful operation ever since they were set to work. As will be seen from the illustration, they are of the vertical cross-compound Corliss low-speed type, having the fly-wheel and generator armature bolted together and mounted on the crankshaft between the main bearings. The normal output of the generator is 500 kw. The engines are designed for an economical load of 780 i.h.p., and a maximum load of 1,000 i.h.p., with a boiler pressure of 150 lbs. per sq in., and working either condensing or non-condensing. These conditions are very onerous, and the engines were also made specially strong to withstand the wide fluctuation in load met with in tramway working. The engines are arranged to run at a normal speed of 90 r.p.m. The high pressure cylinder is 20 in. diameter, and the low pressure 40 in. diameter, and both are 3 ft. 6 in. stroke. The piston rods are 4½ in. diameter, and the crank-pin journals 6½ in. diameter, by 8 in. long. The main bearings are 15 in. diameter by 20 in. long, and the crankshaft is 17 in. diameter in the middle. In order to allow for any inequalities in the settlement of the foundations, the main engine bearings are constructed to slightly swivel, which is also an advantage in such long bearings, in case one bearing wears down faster than another. The valves on both cylinders are of the Corliss type, placed in the cylinder heads, and are actuated by the builder's improved trip gear, with vacuum dashpots. After some months' experience in the running of these two sets, the Sheffield Corporation placed an order with the same firm for another set of 1,000-kw. capacity, and the firm are at present erecting this engine on foundations alongside the two former sets. Messrs. Cole, Marchent & Morley, Limited, recently issued a wall-card illustrating these engines and giving a list of their standard sizes, also a similar card showing their horizontal type of engines. Readers can obtain these on application. Their 500-kw. low speed Corliss engines, which are doing service at the City & South London Railway power station at Clapham, were described in the Electrical Review for September 7th, 1900.



Standard Low-Speed Vertical Compound Direct-Connected Traction Set for Sheffield.



Works Wagon for Heavy Castings.

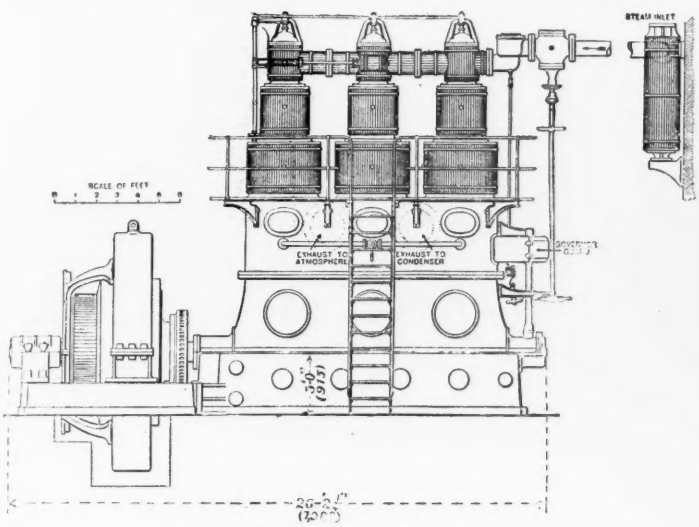
Works Wagons for Heavy Castings.

We illustrate an eight-wheel coupled wagon, which has just been completed by Messrs. S. Rawlinson & Son, wagon builders, Blackburn. Its special interest lies in its extraordinary dimensions. The top of each wagon measures 9 ft. × 5 ft., and is bolted together with 6-in. oak planks and six steel girders 6 in. × 3 in.; it is plated round the sides and ends with 6-in. iron plates. The

top bolsters are made to swivel under load in taking corners. The under-carriage is made to swivel on 3 in. × ⅜ circle plates, and the drawbar on the second wagon can be varied in length to suit various sizes of boilers or castings, as the case may be. The axles are of steel, and measure 5 in. diameter. The wheels are tired with 9 in. × 1½ in. convex tires, and are fitted with gun-metal bushes, each weighing 86 lbs., to receive the axles. The wagons can be detached for carrying short and bulky castings. The coupled wagon is extremely serviceable for carrying boilers, as the wheels, being eight in number instead of four, as in ordinary wagons, are not likely to sink under a heavy load. The weight of the whole structure is 9 tons, and it is capable of carrying a load of 80 tons.

Willans Engines for Electric Traction.

Our illustration shows an elevation of one of the compound 1,200-I.H.P. engines supplied to the Liverpool Corporation Tramways by Messrs. Willans & Robinson, Limited, Rugby. There are in all over 30,000 H.P. of Willans engines at these works, a large proportion being of the size shown, and similar engines have been supplied to St. Helen's, Brighton, Oldham, Nottingham, Bradford, City & South London Railway, and other tramway power stations. This alone would be sufficient to demonstrate the suitability of the Willans engines for electric traction, without further comment. We have seen them at work on a traction load with heavy fluctuations, when the only evidence of a change of load was given by the movements



Willans 1,200-I.H.P. High-Speed Engine.

of the automatic expansion gear, the tachometer remaining practically steady. The prejudice in favour of low speed engines for electric traction, which was so strongly in evidence a few years ago, was solely due to American influence—good high-speed engines being unknown in America—and is now fast becoming extinct in this country; the success of the essentially British practice in this respect is a feather in our caps, of which we may justly feel proud. Experience has shown that the high-speed engine is unexcelled for economy and durability, even under the alleged shocks and stresses inherent to electric tramway running; for example, three Willans engines of 290-H.P. each ran the Hobart tramways for five years absolutely without repairs. At the end of that time only minor parts were ordered; and the station has been running eight years with entire success. So long as the fly-wheel is between the engine and the dynamo, the shocks which certainly occur in the electrical circuits cannot possibly be transmitted to the engine. Even without a separate fly-wheel, however, the Willans engine is perfectly satisfactory, the armature of the generator being generally massive enough to provide the necessary fly-wheel power. As for accurate governing, the ordinary Willans throttle governor gives quite close enough regulation; but if exceptionally steady running is desired, Messrs. Willans & Robinson make use of a device by means of which not only can they make the speed isochronous, but they can even make it increase with increase of load! The high speed of the Willans engine also enables it to answer the governor more quickly than can ever be possible with a low speed engine, as the cylinders take steam so many times per minute that any variation in the load is instantly compensated. Further, owing to the extreme accuracy of the manufacture, every part is perfectly interchangeable without the slightest fitting, so that spares or renewals can be provided from stock. The fact that Messrs. Willans have built, and are building, engines of 3,000 I.H.P. shows that the usefulness of the central-valve principle is not confined to small sizes.

Doulton Conduits and Troughs.

In connection with electric tramway undertakings, the underground feeder cables are in many instances drawn into ducts, and usually spare "ways" are provided for extensions and contingencies. With few exceptions the conduits are of earthenware, the cheapness and durability of which recommend it strongly as a material for underground construction. Multiple conduits of glazed earthenware (stoneware) were introduced into this country some 10 years since by Messrs. Doulton, of Lambeth, and the manufacture has developed into an important industry. Being of hard-burnt glazed stoneware, the Doulton conduit is thoroughly proof against chemical action due to acids and gas found in the soil. It is made with two or more square ducts, and the walls are of sufficient thickness to ensure ample mechanical strength. The ends of each length are rounded internally to permit of the safe and easy passage of the cables. Owing to the grouping of a number of ducts in one block, labour is economised, and a given number of ways is provided within the minimum of space, a feature which is of no small moment in underground work. In some instances the conduits are laid beneath the footways, the lengths being joined together with Portland cement upon stoneware cradles. In traction work, however, a more usual method

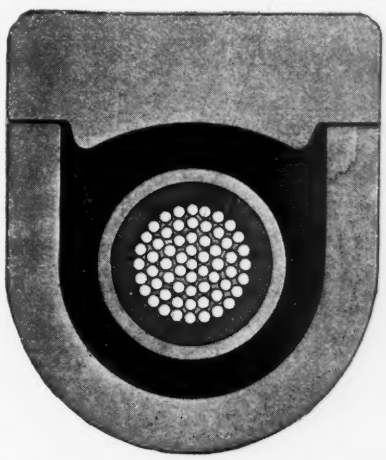


Fig. 2.

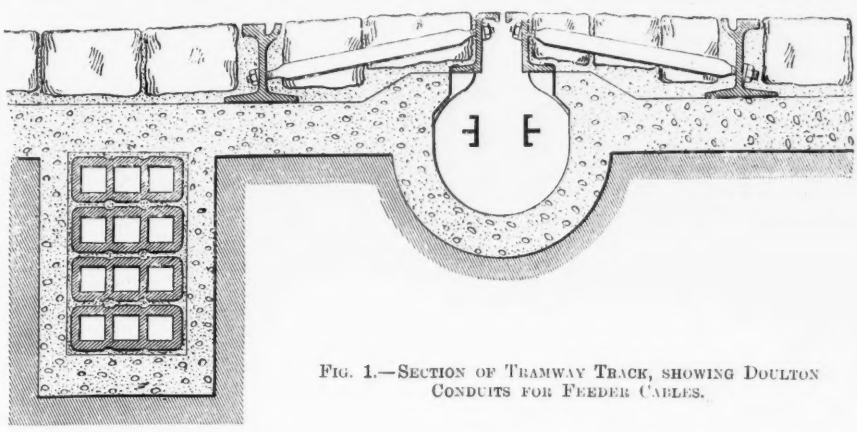


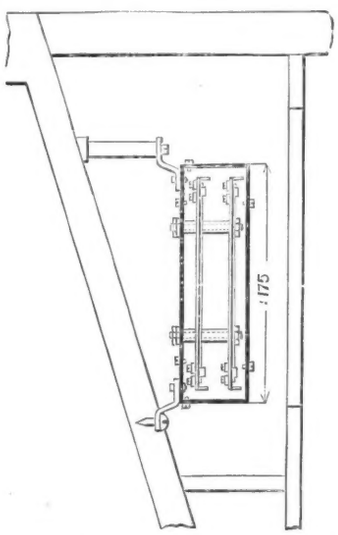
Fig. 1.—Section of Tramway Track, showing Doulton Conduits for Feeder Cables.

is to build the blocks upon a bed of concrete. In this case the joint cradles are dispensed with. This construction is very suitable where many ducts are to be provided, the sections being built up in cement-mortar to the required number. The rectangular shape of the Doulton conduits renders them very suitable for building up in this way. Fig. 1 shows a section of conduit track with Doulton ducts.

In some instances the feeder cables are laid upon the "solid" system, being enclosed in troughs which are filled up with bitumen. Fig. 2 shows a section of feeder cables enclosed in Doulton troughing.

Car Heating.

Messrs. O. Berend & Co., Limited, of Basinghall Avenue, E.C., are the suppliers of the "Prometheus" radiator for electric car heating. It consists of a light iron framework, on which 12 heating strips are placed. The strips are all connected in parallel, and in the event of any one strip breaking down, the rate of heat developed in the radiator is only reduced by about 8 per cent., and a renewal of the faulty strip can be effected in less than two minutes. The patent strips have a very large emissive area, so that the temperature can be kept low, thereby securing long life.



Section of Prometheus Radiator under Seat.

The radiators are encased in perforated protecting covers, and are designed for use on circuits up to 500 volts. Perfect regulation of temperature is said to be secured by the patent three-way connecting arrangement employed, and the radiator is connected to three small single-way switches mounted together on one block, at any convenient place in the car.

Steam Dynamo for Electric Traction.

The accompanying illustration represents a compact, well-designed and well-finished generating set, consisting of an engine by Messrs. Ransomes, Sims and Jefferies, Limited, of Ipswich, combined with a dynamo by Messrs. Laurence, Scott & Co., of Norwich.

The engine is of Messrs. Ransomes' well-known "open type." It is designed to withstand a net pressure of 175 lbs. per sq. in. on the piston, and it will drive a dynamo at normal speed and full output at any pressure above 70 lbs. per sq. in. It is fitted with the makers' "Type B" shaft governor, operating an equilibrium throttle-valve, with an efficiency as proved on test of 2 per cent., the revolutions, under a load of 106 amperes, being 300; under 56 amperes, 302; and when running light, 306 per minute. The hand adjustment allows the speed to be varied between 287 and 325 revolutions while the engine is running. It will be noticed that the design includes ample surfaces, automatic lubrication, and easy accessibility, while splash-guards are carefully arranged to prevent oil-throwing.

The dynamo is of Messrs. Laurence, Scott & Co.'s "four-pole semi-enclosed type."

The design of the dynamo frame, while it uses the metal in the magnetic circuit to the best advantage, gives very good ventilation and ample protection to the armature and magnet coils. The frame is cast in halves, so that the top can be removed to get at the armature. The dynamo is fitted with carbon brushes, and all modern improvements are introduced. The combined plant measures 6 ft. long by 2 ft. 10 in. wide by 5 ft. 4 in. high, and the total net weight is just under 40 cwt.

Switchboard Equipment.

The illustrations on page 987 show some of the apparatus specially manufactured for traction work by Messrs. Nalder Bros. and Thompson, Limited, 34, Queen Street, E.C.

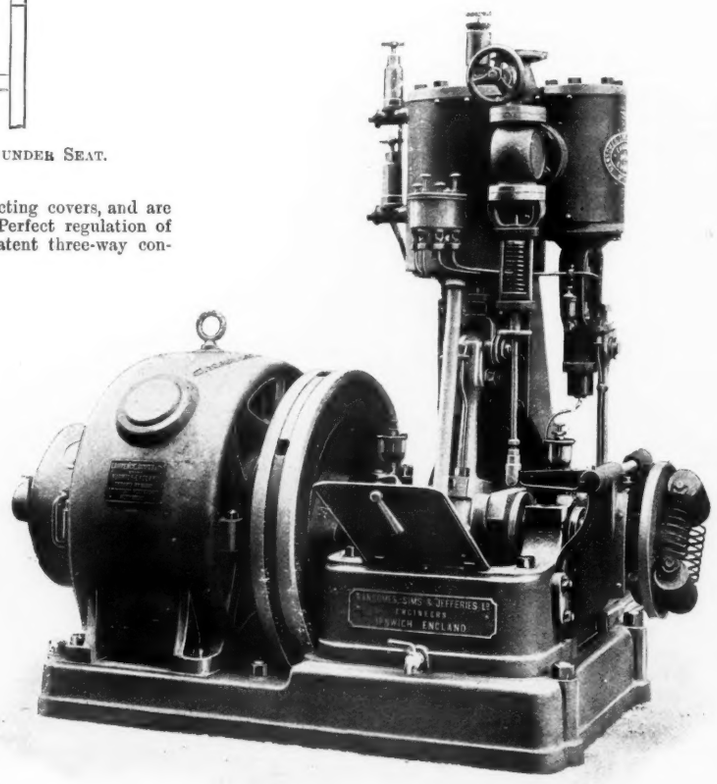
A convenient form of switchboard recording instrument is shown in fig. 1. This is of the permanent magnet moving-coil type, and is suitable for Board of Trade panels; it is also made specially damped for dynamo or feeder circuits.

For high-pressure polyphase work the Ayrton & Mather electrostatic voltmeter is made, in any range, with a large factor of safety for sparking, and can be had with open or even scale as required. This is dead-beat, independent of frequency, and absorbs no power, each instrument being complete with double-pole fuses. Messrs. Nalder also make permanent magnet moving-coil volt and ammeters in numerous forms.

Messrs. Nalder's circuit breakers are on a new principle, and their quick and satisfactory action makes them very suitable for traction work. They are made in overload and underload patterns, as well as for various combinations, such as overload and no volts, or overload and minimum reverse current.

Fig. 2 shows a maximum circuit breaker; the main current passes through the solenoid, and when it reaches the limiting value (which can be previously adjusted by means of the milled-head screw at the bottom of the instrument), causes the iron plunger to fly up and release a detent, allowing the switch to fly out. The quick-break is achieved by means of a compressed spring in the cylindrical chamber shown. The arc at breaking is taken by the carbon blocks at the side of the contacts. The current density in these circuit breakers is extremely low, being only 30 to 40 amperes per square inch.

Fig. 3 represents a polarised minimum cut-out, the action of which is as follows:—The armature is held up against the action of gravity and two springs, by the main current passing through the solenoid, the coil of which for anything above 200 amperes is wound of copper strip. When the current falls below a predetermined value (which can be adjusted), the armature falls away and raises a small lever, which releases a detent and allows a powerful coiled up spring to push out the contact piece, thus breaking the circuit.



Steam Dynamo for Electric Traction.

The automatic is provided with carbon blocks to take any spark at breaking.

The contacts are well laminated, and work at a very low current density, about 30 to 40 amperes per square inch.

Fig. 1.

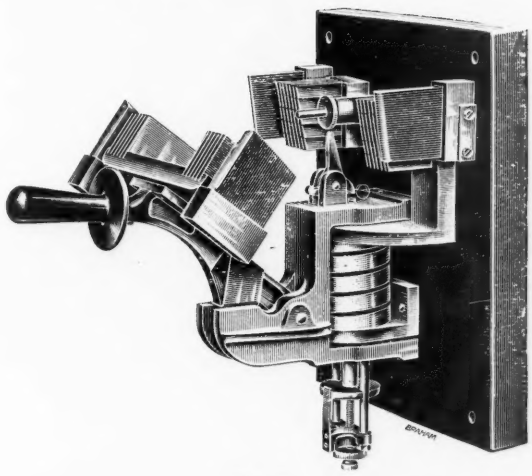


Fig. 2.

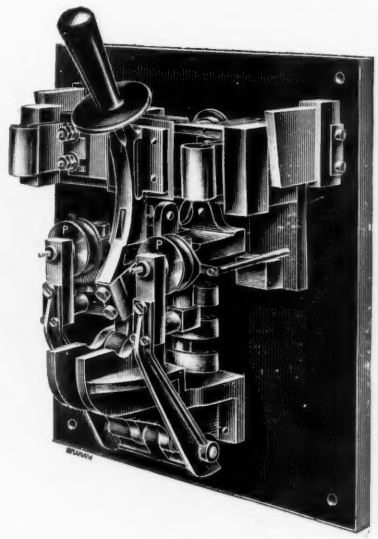
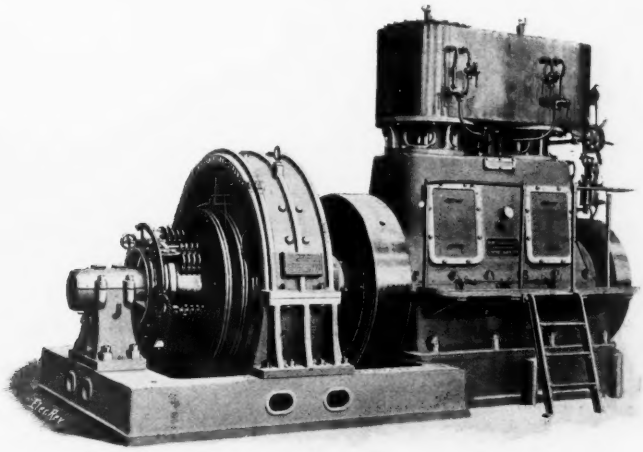


Fig. 3.

The two polarising coils, P, P, are fitted to the minimum switch, and are excited from the bus bars, causing the automatic to hold on even when no current is passing and break circuit at a small reverse current, the advantage of this being that in the event of a sudden back rush of current in the negative direction, the armature being polarised falls away, and there is no possibility of its being held on with a current in the reverse direction, however large, as might conceivably occur if it were not polarised.



Silvertown Traction Generator.

Quick-break knife switches and change-over switches, field-regulating switches and testing panels of the latest and most improved type are also made to suit various requirements.

Silvertown Traction Generator.

We illustrate above a 300-kw. traction generator, made by the India-Rubber, Gutta-Percha & Telegraph Works Company, Limited, and coupled to one of Messrs. Browett, Lindley & Co.'s enclosed high-speed engines. The field magnets are of cast-steel, with pole-pieces of the same material bolted to the yoke. The field coils are wound on sheet metal bobbins, with gun-metal flanges insulated with vulcanised india-rubber. The armature is of the slotted-core barrel-wound type, built up on a cast-iron spider, and the bearings are fitted with self-oiling rings. The machine gives its rated output at 460—500 volts shunt-wound, or 500—550 volts compound-wound, at 350 r.p.m., with a temperature rise not exceeding 70° F. above the atmospheric temperature.

The engine is rated at 450 b.h.p., with 150 lbs. steam pressure, whether condensing or not; the cylinders are 16 in. and 26 in. by 11 in. stroke. The valves are of the piston type, the high pressure valve being controlled by a Begtrup shaft governor, and the lubrication is effected under pressure.

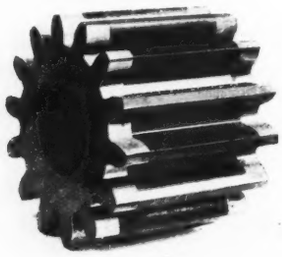
The combination, as our illustration shows, has a handsome appearance, and the makers' names are a sufficient guarantee of quality and workmanship.

New Process Raw Hide Gearing.

With the introduction of electricity as a motive power, the use of cog-wheels has greatly increased, and no doubt this increase would have been at an even greater ratio but for the fact of the accompanying noise and vibration attending the use of metal gears. However, "Necessity is the Mother of Invention," and our American friends proved themselves the pioneers in bringing out pinions of raw hide, which are practically noiseless. These gears have several other advantages, as not only will they wear as long as gears made of any other material, but they will prolong the life of the gears with which they mesh. In a set of two gear wheels, only one need be of raw hide, the other being of any suitable metal properly cut; also, in a train of gears, every alternate gear should be of raw hide, and the rest of metal. When these gears are used the vibration is so materially reduced that the life of the machine is greatly lengthened; this is especially important in the case of the armature of an electric motor, as the armature winding will last much longer with raw hide than when steel gears are used.

For a considerable period these pinions have been in use in the United States in connection with electric motor cars, roller mills, elevators, electric cranes, machine tools, and, in fact, on all sorts of geared machinery, and during the last four or five years they have been employed in largely increasing numbers in connection with electric tramcars, the decreased noise conducing to the comfort of the passengers; indeed, when the fact is mentioned that these pinions are in use on more than 200 electric railways in the United States, it will be seen how they have won their way into favour. They are usually fitted with strong gun-metal flanges, as shown in the illustration below, and are bored and keyed like a metal gear. The material takes almost as fine a finish in the lathe as steel.

There are now two or three different makes of raw hide gears on the market, but we believe the original inventors were the New Process Raw Hide Company, of Syracuse, for whom the well-known firm of Messrs. George Angus & Co., Limited, of Newcastle-on-Tyne, have acted as sole agents for the United Kingdom for some years past, and are now, we believe, in accordance with an agreement with the inventors, manufacturing these articles at their own works. The hides used are prepared by a special and secret



"New Process" Raw Hide Gearing.

process, and are selected *ox* hides, thus ensuring a longer life to the gear than those made from an inferior hide, the preparation of which has no special merit. Messrs. Angus & Co. are also in a position to furnish cast-iron or steel gears, cut to Brown & Sharpe's standard cutters and gauges.

Tower Wagons for Tramway Work.

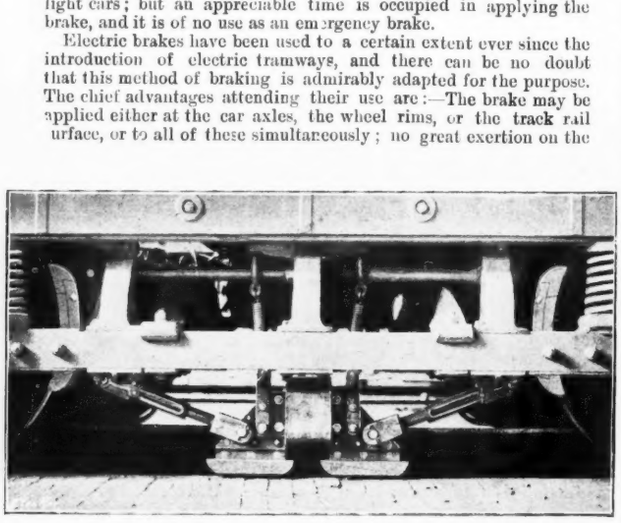
The accompanying illustration shows a tower wagon which is made by Messrs. S. Rawlinson & Son, of Blackburn. The inside wagon can be lifted to a height of 18 ft. by one man, and is secure at any intermediate height. The tower is lifted by means of a vertical screw, no locks being required. The guard rails are made to fall down when required, so as to pass under arches or any other confined places. The wagon is fitted with a good lever brake, and a 5 ft. locker the whole width of the wagon.

The Westinghouse Magnetic Brake for Electric Tramcars.

Since the introduction of electrical traction with its larger, heavier tramcars and high speeds, the frequency and severity of accidents due to failures and ineffectiveness of the car brakes have been very marked.

Hand-brakes have the advantage that they are cheap and simple, and they are adjustable to a nicety for the normal slow braking of light cars; but an appreciable time is occupied in applying the brake, and it is of no use as an emergency brake.

Electric brakes have been used to a certain extent ever since the introduction of electric tramways, and there can be no doubt that this method of braking is admirably adapted for the purpose. The chief advantages attending their use are:—The brake may be applied either at the car axles, the wheel rims, or the track rail surface, or to all of these simultaneously; no great exertion on the



Westinghouse Magnetic Brake.

part of the operator is required to apply the brakes; the brakes cannot be applied while the car motors are receiving operating current; the brake action is instantaneous, one motion of the lever cutting off the motor current and bringing the brakes into play; the braking effect is adjustable, and is of a certain definite strength, according to the will of the driver. Thus the electric brake can be used as the quickest and strongest of emergency brakes, or as the gentlest in action for normal slow stops.

The general construction of the Westinghouse magnetic brake for tramcars is shown clearly in the foregoing figure. It consists essentially of a horse-shoe electro-magnet suspended by springs from the car frame. The poles hang downwards immediately over the track rail head. The magnet is connected by an arrangement of levers with the brake blocks of the wheels on either side of the magnet. This practically forms the whole of the brake mechanism, and it is evident that it is neither very heavy nor cumbersome, nor is it at all fragile or delicate in any detail. The brake is applied by moving the lever of the car controller backwards beyond the "off" position; thus the brake cannot be applied while the car motors are receiving current. The supply current is cut off the motors by bringing the controller lever round to the "off" position; continuing the motion of the lever beyond this position arranges the connections so that the current given out by the car motors, now running as generators driven by the momentum of the car, is caused to excite the electro-magnet of the brake. A series of definite steps is arranged for the backward motion of the controller handle whereby the strength of the current round the brake magnet may be varied at the will of the driver, suitable resistances being placed in circuit with the brake magnet coil at each step of the controller handle. The effect of exciting the brake magnet is to cause it to be drawn down to the track rail beneath. A track braking is thus secured, which is variable in intensity at the will of the driver, and which does not depend upon the weight of the car, nor does its application reduce the effective weight of the car, or the grip of the wheels on the rails. The drag of the electro-magnet on the track rail is taken up through the system of levers by increased pressure on the brake blocks of the wheel rims. The braking effects on the track and wheel rims respectively can be adjusted proportionally to give the best results, that is, to allow for the maximum wheel-braking effect without skidding. These adjustments are required owing to the different types and weights of cars in use, and because of the excessive gradients on some lines. In addition to these two braking effects, there is the one which is occasioned by loading the car motors as generators. This brake is adapted for slow stops as required in normal service, and also for the most rapid emergency stops ever likely to be required. It will be seen that the higher the car speed at braking the greater will be the emergency braking effect. The action of the brake is identical for either direction of car running, no changes whatever being necessary when the car direction changes from forward to backward

Tower Wagon for Tramway Work.

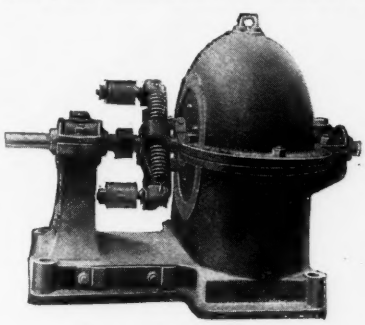
running, or *vice versâ*. The brake is silent in action and causes no vibration. It is an impossibility for the brake gear to fail and apply itself automatically. Owing to the extreme simplicity and non-wearing nature of the brake and its parts, great reliability in action is secured, and it is distinctly economical in operation, since it uses only that power which would otherwise be wasted.

The Cassel Constant Speed Water Motor.

A loss of water in governing turbines and other water motors is unavoidable, owing to the incompressible and inelastic nature of water, which produces dangerous shocks and strains in the pipe line and controlling mechanism whenever the flow of the water is reduced, unless some means of relief is afforded. In the Cassel constant speed water-wheels this loss is reduced to a minimum, and the method of so doing eliminates all risk of trouble in the pipe line, and all danger of over-running the driven machinery. The wheel is made in halves, which are moved apart whenever the speed exceeds the normal, so as to allow part of the water to pass through. The movement of the buckets is effected by increased centrifugal force, due to any given increase of speed acting against the tension of springs tending to keep the buckets close together.

In cases where an abundant supply of water is obtainable, it is claimed that the Cassel wheel is absolutely without a competitor.

In cases where the supply of water is intermittent, or subject to great variations in volume, and is accumulated by means of a reservoir built at the head of the fall, it is necessary, apart from speed regulation, to introduce some arrangement for governing the *use of water*, so that the consumption may be in proportion to the load on the wheel. To this [end] an extremely simple apparatus has been designed by Mr. Cassel, the operation of which is controlled by the position of the buckets, and which reduces or increases the



Cassel Water Motor.

flow of the water when any decrease or increase of load takes place, until the volume of water flowing is just sufficient to run the wheel at normal speed with closed buckets. By this means the efficiency of the wheel is kept up to the highest possible point. A full description of the apparatus was given in our issue of July 12th, 1901.

A hydro-electric plant has been installed, for demonstration purposes, at the offices of the company's consulting engineer, Mr. Ed. C. de Segundo, 28, Victoria Street, Westminster, consisting of a Cassel wheel, driving a dynamo driven by a belt. Fig. 3 is taken from a photograph of this Cassel wheel, and the company are pleased at any time to show it in operation, and to give full particulars of the cost, &c., of power plants to be operated under any head of water.

The Cassel Self-Regulating Water-Wheels, Limited, 56, Broad Street Avenue, London, E.C., are the owners of the world's patents for this invention; in Europe a French company has already been organised to work the French patent rights, and has in hand some important work in connection with electrical traction on a large main line of railway, and other matters of equal magnitude, while in America the company has recently secured, amongst other orders, the contract for a large hydro-electric power plant, the units being of 2,400 kw. each, and the Cassel water-wheels which drive them direct being operated under a head of 2,000 ft. of water.

The Cassel wheel is, perhaps, one of the most interesting departures in the design of water motors that has been brought to the notice of engineers of recent times.

Tramway Type of Crane.

We illustrate a crane of 3 tons power, which lifts its load at 16 ft. radius, free on rails, the gauge being 4 ft. 8½ in., without the use of clips or packing. It is of up-to-date design in every detail. Current is taken from overhead trolley lines by a standard tramway type pole, an interesting feature being that the return current is also conveyed by the trolley and line. All motions of the crane are driven by a 25-h.p. series-wound motor, a standard controller being used to stop, start and regulate its movements. The travelling motion is by steel, spur and bevel gear. The derrick motion is by steel and phosphor bronze mitre and worm gear, being self-locking and absolutely safe in all positions. The particular crane represented by the engraving is employed in the yard of a steel foundry, for which work it is eminently suited. Messrs. Jessop & Appleby Bros. (Leicester and London), Limited, of 22, Walbrook, E.C., were the manufacturers.

Electric Travelling Crane.

The Sorge-Cochrane System of Water Purification.

Messrs. Erith's Engineering Company have introduced the above modification of their well-known Cochrane heater and purifier, which has been very extensively adopted in British steel works, collieries, electric lighting and power stations, and by steam users generally.

The standard Cochrane heater arrests the temporary hardness in the form of carbonates or soft scale, by the mechanical action of the heat in exhaust steam first freed from oil, and then brought into direct contact with the feed water. No lime whatever is needed for this softening process. But when, in addition to temporary hardness, the water contains permanent hardness in the form of sulphates or hard scale, chemical action is necessary; and the Sorge-Cochrane system, of which some 200,000-h.p. capacity is already in commercial use, furnishes an extremely simple, compact and reliable method of positively arresting all scale-forming matter in the boilers.

The illustration on the next page shows a 300-h.p. plant, which occupies the extremely small space of 9 ft. × 4 ft. × 17 ft. high. Various other sizes from 100 to 3,000-h.p. capacity are made, and even the largest size only occupies 16 ft. × 9 ft. ground space.

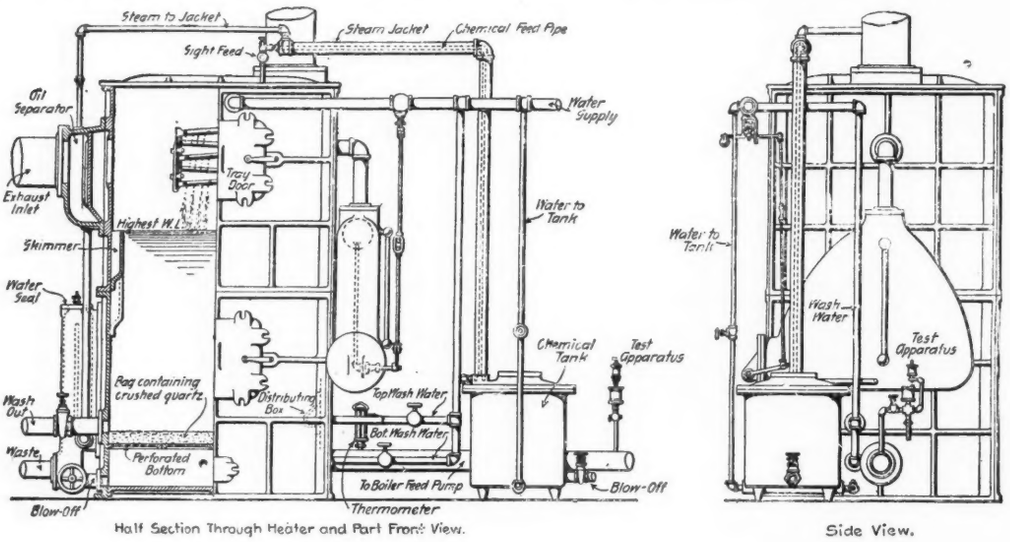
The reason for this extraordinarily small space lies in the fact that the complete reaction, precipitation and settlement, which would take about 9 hours with water at 100°, can be equally well accomplished at 200° in about 10 minutes only. Exhaust steam is used to give this temperature, and the fuel saving due to this heating is about 15 per cent. as compared with cold water feed, or about 6 per cent. as compared with ordinary tubular heaters which give no purification.

A further reason for treating the water at about 200° is that, at this temperature, the carbonates of lime and magnesia are arrested very thoroughly without the use of chemicals, and so no lime is needed, as explained above. It is also known that the carbonates are deposited more perfectly in an alkaline than in an acid or neutral water, and that they remain in solution if the water

contains free carbonic acid. All these points are taken into account in this system.

At the temperature of 200° F., the free carbonic acid is driven off by the vent to atmosphere at the top of the Cochrane heater. Ordinary soda-ash in regulated proportions is introduced, the water being made slightly alkaline. The hard scale-forming matter, viz., deposits being in the form of flocculent mud, this washing out is easily done. Periodically a thorough washing out with a hose pipe is usual, in addition to the daily rough-washing; and such a thorough cleaning can be done within an hour, the heater being very easily opened, and all parts being readily accessible.

Particular attention is directed to the simplicity of the testing



Half Section Through Heater and Part Front View. Side View.

Sorge-Cochrane System of Water Purification.

the sulphates of lime and magnesia, are thereby changed to carbonates, which in turn are arrested and percipitated as explained above.

The corrosive materials, such as chloride of magnesia and sulphuric and carbonic acids, are also provided for. The carbonate of soda takes up all the sulphuric acid, forming sulphate of soda and carbonic acid gas, which latter is driven off through the vent by the heat. Any chloride of magnesia present is changed by the carbonate of soda (soda-ash) to carbonate of magnesia, which, under the conditions, is precipitated. The liberated hydrochloric acid goes to the soda to form sodium chloride, or common salt, which is not injurious to the boiler under ordinary conditions.

As will be seen by the illustrations, the apparatus consists of a Cochrane open feed-water heater, into which exhaust steam is introduced through an oil separator, furnished with a water-seal to remove the oil. When no exhaust steam is available, live steam through a reducing-valve can be used to heat the water.

The feed-water passes over a series of trays, which divides it into drops, thus ensuring proper heating. A float in the outer float-box controls the supply of cold feed-water according to the demands of the boiler feed-pump.

The soda-ash solution comes from a chemical tank holding a day's supply, and is fed by a cold-water pipe with a controlling valve, through a sight-feed glass, into the trough of the heater which receives the cold feed-water. It has hitherto been found very difficult to feed soda-ash in a uniform manner, on account of variations in the strength of the solution. The Sorge-Cochrane system, however, has quite overcome this trouble. It is a known fact that to get uniformity a concentrated solution must be made; further, that a concentrated solution of soda-ash at 60° is a dilute solution at, say, 100°.

Therefore, in this system, the concentrated solution is made in the chemical tank at, say, 60°, and is led to the heater in a steam-jacketed pipe, thereby raising the temperature of the solution after it leaves the chemical tank, to such a point that it is a dilute solution when it enters the heater; moreover, under these conditions it does not deposit and fill up the pipe. Absolute regularity is thus secured, irrespective of the quantity of soda-ash remaining in the chemical tank.

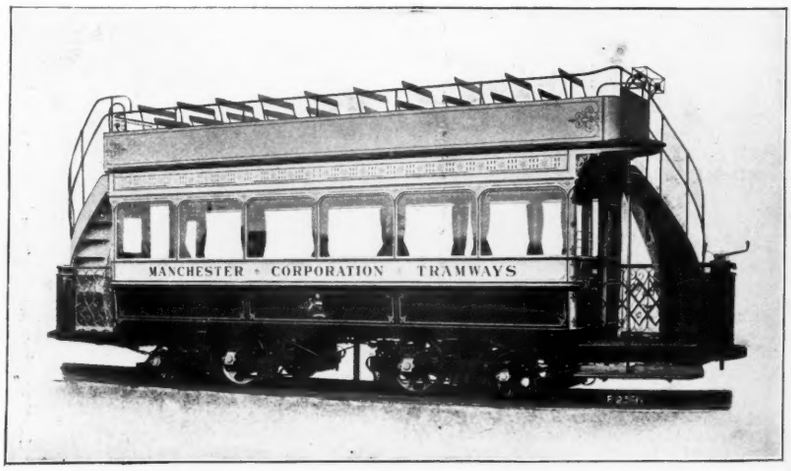
With the high temperature used in the heater, the chemical reactions at once take place; the softened water descends and forms a large pool above a specially-prepared filter bed, ample time being given for complete precipitation under the conditions described. The softened water finally passes to the feed-pumps and thence to the boilers, passing through the filter-bed of quartz, shown in the figure.

To avoid frequent stoppages for cleaning, provision is made for washing out daily the accumulations of scale, as indicated. All the apparatus. Any fireman can make tests as to the condition of the water, no chemical knowledge being needed from the attendant.

By turning a cock, the softened water flows into a small glass cup. Above this cup is a smaller one filled with solution of phenol-phthalein in alcohol. A drop of this falls into the cup of treated water. So long as there is any acid in the water, or so long as it is neutral, no reaction occurs, and the water remains clear; showing in such case that more soda is needed. If there is a slight excess of carbonate of soda, a faint pink tinge indicates that the correct amount of soda has been fed. A deep red tinge indicates that an excess of soda has been fed. Thus the feeding of the soda-ash can be regulated correctly, to suit the varying condition of the feed-water, and absolute prevention of scale in the boilers is assured. The cost of soda treatment is quite nominal.

It is needless to mention the losses caused by scale in boilers, and the saving made by complete purification of the feed-water. Hitherto the objections have been due to the great bulk, heavy cost, complicated mechanism and irregular working of many purifiers, and the skilled attention they demand.

In the Cochrane-Sorge system there are no stirrers or other mechanism; the space is trifling, the cost very reasonable, the process under entire control. No lime is used, the only chemical being ordinary soda-ash. Any boiler attendant can make the colour test described above



Electric Tramcars at Manchester.

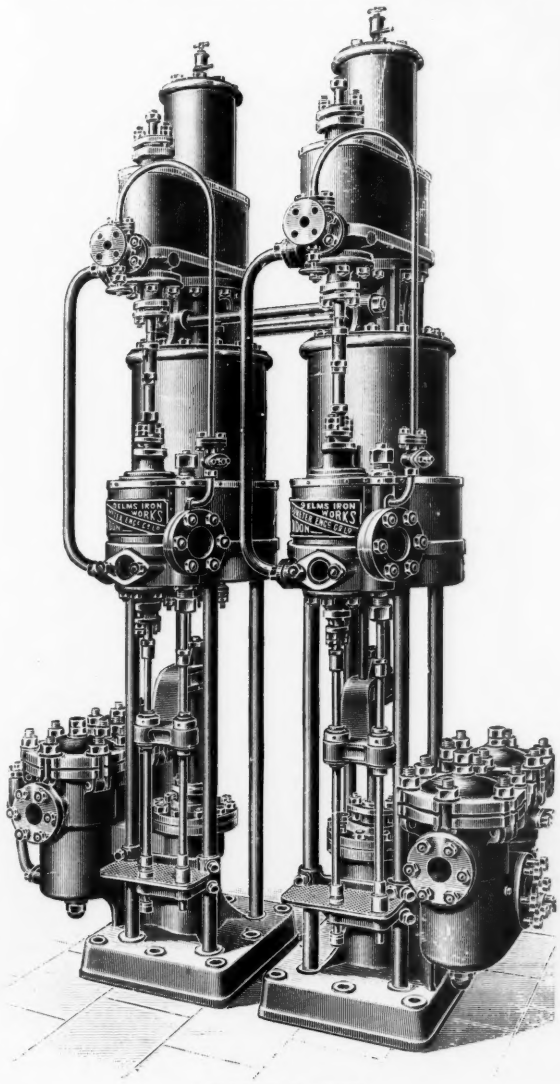
The various features are covered by patents in various countries; and as stated above, some 200,000 H.P. of boilers already use this system, so there is no experiment. Full particulars can be had from Erith's Engineering Company, 70, Gracechurch Street, London.

The Electric Tramcars at Manchester.

A few years ago the manufacture of electric cars in this country was not so well provided for as it is to-day, and in consequence many important car contracts found their way out of the country. Since then quite a number of new factories have been erected in different parts of the provinces by old and new companies, and one of the first to proceed in a business-like way to prepare for the contracts which were coming along was the Brush Electrical Engineering Company. The old barns, so to speak, were pulled down and greater built, until to-day the annual capacity of the Loughborough car factories is large indeed. The Manchester Corporation electric tramways, the first section of which was opened only a month or two ago, when all is completed, will have some hundreds of cars in operation, and 220 of the car bodies are being built by the Brush Company. Others, we believe, have been furnished by Messrs. G. F. Milnes & Co. Our illustration on p. 990 shows a double-decker Brush car for this city.

Pulsometer Pumps.

The compound tandem feed-pumping engines made by The Pulsometer Engineering Company, Limited, of Nine Elms Iron Works, Oxford Road, Reading, Berks, are made in six standard sizes, the smallest being designed to feed boilers of from 500 to 1,000-H P., whilst the largest at present made is capable of feeding boilers of 5,000 H.P. They are very economical, the steam consumption being considerably less than 50 lbs. of steam per water H.P.-hour,



Pulsometer Pumps.

and in some instances only 45 lbs. of steam per water H.P.-hour have been used. Expressed in other terms this would mean that with a steam pressure of, say, 150 lbs. to the square inch, 130 lbs. of water will be put into the boiler for each pound of steam used.

The Pulsometer plants are successfully working at some of the largest power stations in London. The company are also large makers of condensing plants and pumps, both steam and electrically-driven, for every kind of purpose.

Small Electric Locomotives.

Messrs. Thomas Parker, Limited, of Wolverhampton, have made various designs of electric locomotives, of which we show photographs of three. Fig. 1 is a type supplied for gold mining in South Africa. The weight of this locomotive is about 3½ tons, and it is capable of hauling a load of 15 tons up a gradient of 1 in 50 at a

Fig. 1.—Gold Mining Locomotive.

speed of six miles an hour. The gauge can be arranged for either 18 in. or 2 ft. as desired. Sand boxes and a powerful brake for all four wheels are provided. The driving and reversing switches are operated by one handle. The motor is wound for 550 volts, and is geared by double reduction wheels on to each axle. The open sides and sun curtains are suitable for hot climates.

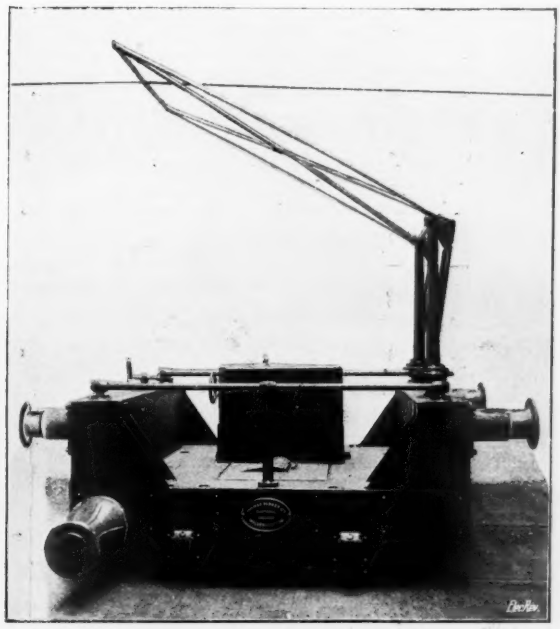


Fig 2.—Shunting Locomotive.

A contractor's locomotive, which was designed and built by Messrs. Parker to the specification of Messrs. Burstall & Monkhouse for the contractors of the Waterloo and Baker Street Railway, Messrs. Perry & Co, to be used in underground work, had a total width of 3 ft overall. The gauge of the rails is 18 in. in this case. The motor develops from 15—20 B H P., and gives a speed on a level of 10 miles an hour. All of the working parts are enclosed and are dust and waterproof. The light iron canopy is detachable so that it can be taken off when the locomotive is required to go through a small

opening. The motor is geared on to the two axles in the same manner as described in fig. 1.

In fig. 2 is illustrated a locomotive for use in shunting from the main line over a private works siding; the gauge being 4 ft. 8½ in.; it was built by Messrs. Thomas Parker, Limited, for Messrs. Lowdon Bros., of Dundee. A capstan will be noticed on the side framing of the loco, the object of this being to empty the trucks at the end of the journey and raise the bags which the trucks contain to the upper storeys of a building. The capstan is geared on to the motor by means of a clutch in such a manner that the capstan can work when the motor is out of gear with the locomotive wheels.

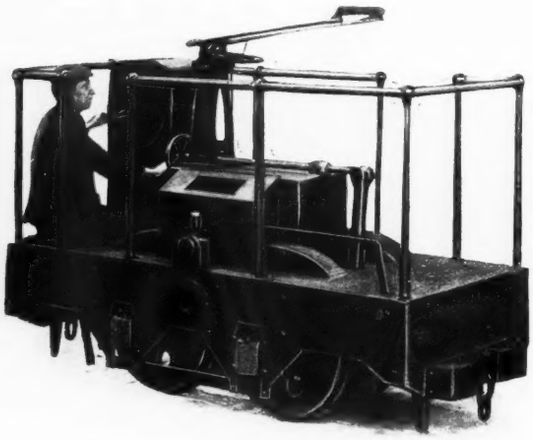


FIG. 3.—LOCOMOTIVE FOR SILVER MINE.

Fig. 3 represents a small loco. designed and built by the same firm for silver mining in Australia. It is suitable for underground work, and will develop 15 B.H.P. at a speed of four to five miles an hour. The gauge is 1 ft. 5 in., and the locomotive is weighted so as to be capable of hauling 18 trucks, each weighing 25 cwt. gross. The gearing is double helical on to each axle. Sand boxes and brake gear to all four wheels are provided. The motor is of the two-pole type suitable for 220 volts, and is water and dustproof. The frame is built up of a cast-iron body with bearings for the counter-shafts cast on either side and provided with loose caps. On the body are bolted rolled steel plates carrying steel horn blocks and axle boxes. The complete weight of the loco. is 3½ tons.

All the motors of the above locos. are wound with Eickemeyer coils, of which Messrs. Thomas Parker, Limited, own the patents for the United Kingdom, and which enable the armatures of even the two-pole machines to be reduced in length, a matter of great importance in the small locomotives because of the narrowness of the gauges.

E.P.S. Batteries for Traction.

THE illustration (fig. 1) shows a battery of E.P.S. cells which were erected in connection with the generating plant of the Liverpool Overhead Railway. In this case the battery is arranged in two halves, each of 248 cells, the switching arrangement being so arranged that each half can be alternately withdrawn during the period of light load, and charged by means of a booster. The introduction of this battery has enabled the station to be worked with 25 per cent. less engine plant than was employed before the battery was installed. The battery as a whole is capable of giving 1,300 amperes for one hour, or 780 amperes for three hours, and the output frequently reaches 1,100 amperes three or four times in a minute.

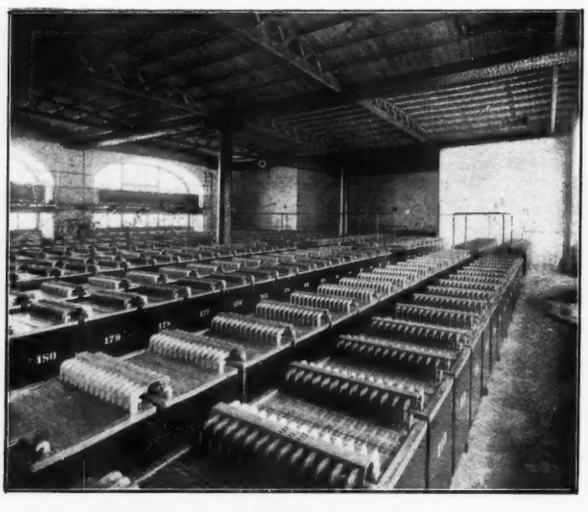


FIG. 1.—E.P.S. TRACTION BATTERY.

For smaller stations a reversible booster is used in conjunction with 240 E.P.S. cells. A diagrammatic arrangement of the connections of this booster is given below, and it will be seen that it is so arranged that the main current going to the line, when it exceeds a certain limit, overcomes the shunt winding of the generator portion of the booster, causing it to give an E.M.F. in the direction which is necessary for assisting the battery to maintain the pressure on the mains. When, therefore, there is nothing going out to the line, and until the limit mentioned above is reached, the shunt of the generator portion of the booster is so arranged as to make the booster assist the line pressure in charging the cells. In practice it is found useful to take the opposing coil from the main circuit as a shunt off a resistance; by varying the amount of the shunt it is possible to obtain the reversing point of the booster at any desired current, so that at various periods of the day when the load varies considerably the current at which the booster reverses is altered by the switchboard attendant, thus ensuring that the plant is always working under the most economical conditions. This arrangement is in use by the Birkenhead Corporation, and is now being installed for the Yarmouth Corporation. In very few instances, however, is the extra expense and complication caused by a reversible booster really necessary, as it must be remembered that although the booster helps the battery to discharge at or near its one-hour limit, it must consequently be working the battery very hard, and it is claimed that if the money which is spent on the boosters and switching arrangements is expended in putting in a larger battery, the battery will be sufficiently elastic to give all the regulation that is necessary, and at the same time, owing to its being larger, it will not be worked to the same extent. The amount of special charging necessary is not very great, some stations working from 10 to 14 days without special charge, and then only requiring an hour or two to bring the cells up to gassing point.

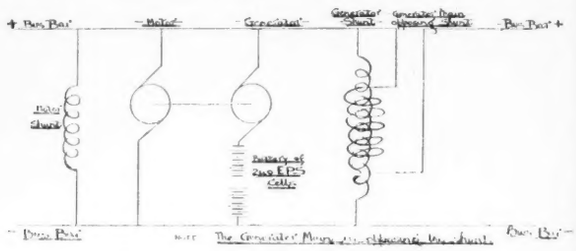


FIG. 2.—REVERSIBLE BOOSTER SYSTEM.

A battery of 244 E.P.S. cells, supplied by the Electrical Power Storage Company, of 4, Great Winchester Street, E.C., has been at work nearly four years on the Liverpool Corporation Tramways. In this case the battery is kept floating on the bus bars, the voltage of the line varying between 500 and 520 volts, and the battery being charged by raising the voltage of the shunt-wound machines after the running of the cars is finished. The output from this battery is 480 amperes for one hour, or 300 amperes for three hours.

100-kw. Motor-Generator for Traction Work.

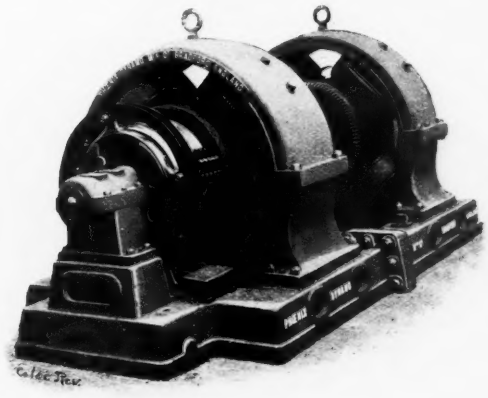
THE illustration on p. 993 shows a motor-generator recently turned out by the PHŒNIX DYNAMO MANUFACTURING COMPANY, of Bradford. This set was supplied to the order of the Bradford Corporation, and in accordance with the specification prepared by Mr. R. A. Chattock, the city electrical engineer. The output of the generator is 100 KW. at 550 volts, the motor end receiving current at 460 volts pressure; it is placed across the "outers" of the three-wire system, the middle wire being earthed. The combination runs at a speed of 500 revolutions per minute. The generator is used for traction work, one pole being, of course, earthed, the main use being for running at night (when the tramway generating plant is shut down) off the 460 v. lighting plant or battery, to supply current for one or two late or special cars, and for shunting cars at the depôts and lighting the latter, &c.

As will be seen, the combination is of the double field type, each having four poles with slotted drum armatures barrel wound, the diameter being 28 in. for either armature. The commutators are 24 in. diameter, having 300 segments, and were hydraulically pressed up while at a high temperature, by which means a sound job was obtained.

An interesting point in connection with this set is that, by means of special designing, the armatures and field coils in generator and motor are alike and interchangeable; thus one spare armature and one field coil only are necessary, where in ordinary cases two of each would be required. There are three bearings fitted and two couplings, the shafts are consequently of equal length.

The bearings are of the spherical or self-aligning type, the seats being of the best Babbitt metal, with which the phosphor-bronze bushes are also lined.

The brush-gear is of the parallel motion type, arranged to give great wearing depth to the brushes, the tension or pressure on each carbon being easily adjusted and fixed. There are four brush spindles on each machine, the armature being parallel wound.



Phœnix Motor-Generator for Traction.

The specified and obtained results of tests are detailed below:—

	Specified.	Obtained.
Full load efficiency	86 per cent. (combined)	86 per cent.
Three-quarter load efficiency	82 ,, ,,	83·9 ,,
One-third load efficiency ..	72 ,, ,,	72·5 ,,
Temperature rises after 12 hours' full load.		
Armature	75° F.	42° F.
Fields	75° F.	45° F.
Speed	500 revs.	490 revs.

With the set was also supplied a two-panel switchboard containing the usual instruments—circuit-breakers, starting switch, and D.P. main switches, also shunt regulators, &c.

The "Stockton" Accumulators.

The latest addition to the roll of accumulator manufacturers, is the firm of Ashmore, Benson, Pease & Co., Limited, of Stockton-on-Tees, who have been established as makers of gas plant, and general engineers, for many years; having made a speciality of gas storage plant, they have now taken up electrical storage plant.

The cells as now made, known as the "Stockton" type, are the invention of their manager, who has devoted himself to the manufacture of accumulators for over 10 years, and has had experience with several of the largest battery manufacturers. The Stockton positive plate is of the Planté type, and is manufactured by the well-known electro-chemical methods which have been successfully used for many years. The negative plate is of the pasted type, and beyond an excellent form of grid, out of which the paste cannot fall, does not materially differ from those of other manufacturers.

The advantages claimed for these cells are purely mechanical, and therefore do not depend upon any chemical action which may, or may not, be beneficial in the long run. The aim has been to produce a cell, which, while following closely the most approved methods of accumulator manufacture, will show an improvement in respect of overcoming faults which develop in cells already on the market. The advantages claimed are:—(1) The positive plate is mechanically strong; (2) The design enables a heavy discharge to be taken from the plate, because of the number of bars of ample conductivity which intersect the plate in all directions; (3) Troubles caused by portions of peroxide scale getting lodged between the plates are avoided by breaking up the scale into very small pieces which fall to the bottom. This is effected by avoiding any plane surface on the face of the plate, and is the object of carrying the horizontal bars of small section across the faces of the heavy bars; (4) Scale can accumulate at the bottom of the cells until over 3 in. thick before the plates can be touched; (5) The plates cannot buckle, because they are effectually tied together; (6) The cost of erection is reduced to a minimum. There are no bottom blocks to fit; no sections to assemble; no separators to be put in place; and no loose glass plates. The sections are sent out assembled with separators in place. Erectors have only to take sections out of the packing cases, and place them in the boxes so that the lugs rest evenly on the top edges.

The conductivity of the plate is assured by casting it in one piece. We understand that the plates are not costly to manufacture, and the latest developments in labour-saving appliances have been installed.

The following details are furnished to us:—

Weight of positive plate, 8 lbs.
Weight of negative plate, 6 lbs. 4 oz.
The output of positive plate as certified by independent engineers:—

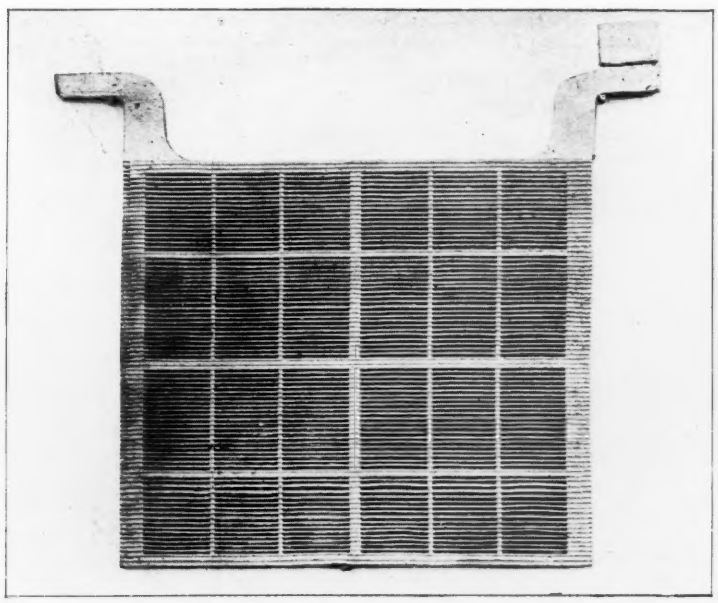
70	A.H.	in	10	hours,	final E.M.F.	1·85.
60	,,	,,	6	,,	,,	1·8.
48	,,	,,	3	,,	,,	1·75.
35	,,	,,	1	,,	,,	1·7.

Crompton Electric Arc Lamps for Traction Circuits.

Everyone who has had to do with the problem of satisfactorily running arc lamps off traction circuits, in many cases suspended from traction poles, knows that, unless a lamp is suitably made for the purpose, it is liable to give trouble. Messrs. Crompton and Co., Limited, of Chelmsford, have adapted their standard arc lamp for running off traction circuits, and lamps both of their open and enclosed types are meeting with an unusual amount of success.

The lamps can be either arranged for suspending from a traction pole or supplied with a screwed pipe for rigidly fixing into the pole sockets, and in some cases the company recommend the lamp being supported by a special suspender for protecting the lamp from vibration.

The clutch of the enclosed lamp has been specially designed for withstanding the vibration met with when the lamp is suspended from traction poles, and this lamp has proved very successful for the purpose.



"Stockton" Accumulator; Positive Plate.

"Chelmsford" Enclosed Arc Lamp.

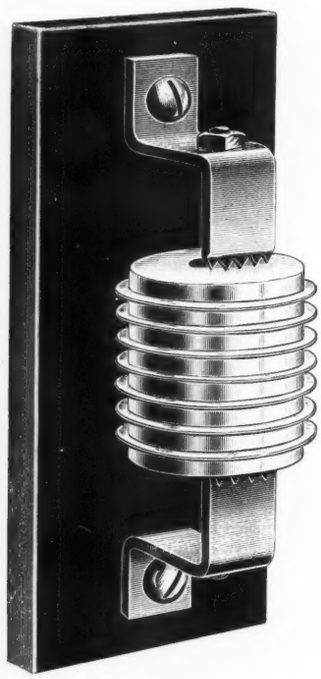
The enclosed-type lamp is made with a special hood above it, arranged to take either the regulating or the substitutional resistance. In many cases it is desirable to have the lamp and resistance in one, and as Messrs. Crompton & Co., for mechanical reasons, prefer not to insert the resistance inside the lamp, they have devised this special hood, which to all intents offers all the advantages of having

the lamp and resistance in one. This hood is supplied with a screwed pipe for fixing into the socket of the lamp bracket or pole, and the lamp can either be suspended from this, or rigidly attached to it.

The figure on p. 993 shows one of Messrs. Crompton's enclosed arc lamps without the special hood, for suspending from a traction pole or bracket in the ordinary manner.

Electric Tramway Accessories.

Controller Cables for Cars.—Messrs. R. W. Blackwell and Co., Limited, of 59, City Road, London, E.C., have just issued a circular describing a new form of the above, which they are making in England, known as the "Jointless." The following particulars will be of interest to tramway engineers and managers:—

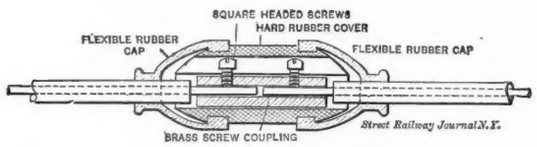


Shaw Non-Arcing Lightning Arrester.

In the ordinary sets of car cables the connections from the main wires to the motors are made by short lengths of cable with **T** joints inside the hose. In the "Jointless" car cables the usual single length of wire inside the hose is replaced by two smaller wires, A A^1 and B B^1 (see fig. on next page), the combined capacity of which equals that of the single wire. One of these wires, B B^1, is carried straight through the hose; the other is brought out in a loop through a hole in the hose at the point M, and the insulation at the top of the loop is bared so that connection can be made as desired. When the connection is made the wire is pulled tight at each end, A and A^1, thus drawing up all the slack beneath the car, and preventing any tendency to vibrate, shake loose, or short-circuit. After drawing the cable tight, the two ends, A B and A^1 B^1, can be cut to exact lengths and connected together by means of the special terminals C which are provided. These terminals are then connected to the controllers. In case of a breakdown, any one wire can be replaced at once without disturbing the other connections. If A A^1 develops a fault, a new length of wire is attached at the end A, and the damaged cable is then drawn out first at M and finally at A^1, the new length being thus brought into position ready to be connected up. The cables are of the best quality, 750-megohm grade, vulcanised, taped, and braided. Each hole in the hose through which the wires are taken is closed by means of a leather **T** piece, thus making the complete hose waterproof. The chief advantages which are claimed for the "Jointless" car cables are: Absence of joints inside the hose; ease with which damaged lengths of cable can be replaced; superior flexibility as compared with old type; the necessary holes in the hose are so small that they can be closed in with a leather **T**-piece, and made absolutely waterproof; the cables are practical and simple.

The absence of joints inside the hose will appeal to anyone who has used the old type with **T**-joints, and has had to remove a defective wire in order to replace it by a new length.

Guard Wire Fittings.—Though opinions are divided as to the value of guard wire, still, as long as it is specified, the object of engineers must be to make it as neat as possible. The patented clips illustrated on the opposite page have been designed by Messrs. R. W. Blackwell & Co., Limited, to meet the want for a neat, efficient and secure guard wire clip which, though easily fixed, will absolutely prevent the wires from slipping. The bolt is slotted so that the wire can be at once placed in position, and all that is required to secure the clamp, is to put on the washer and tighten the nut. The figure is approximately $\frac{3}{4}$ full size, and shows the fitting for straight lines.



Cable Connector Insulator.

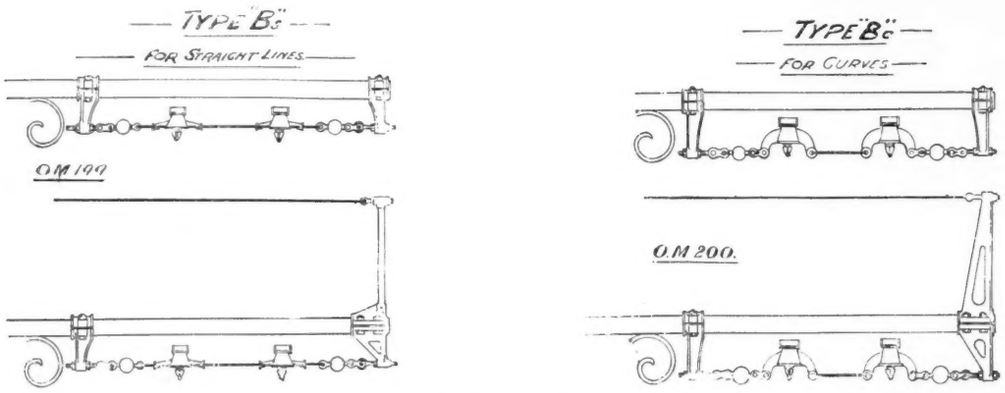
Flexible Suspensions for Trolley Wire.—For some time past there has been a tendency to depart from the old system of attaching trolley wires rigidly to bracket arms by means of bracket arm hangers. The latest methods of suspending trolley wire have aimed at obtaining as much flexibility as possible, in order to get rid of the jar of the trolley head passing over the ear.

This flexibility has been obtained by arranging a small span on the end of the bracket arm, and using straight line hangers or pull-offs in the same way as on a span-wire system. In order to suspend this short span wire on the bracket arm, special hangers have been used, the design generally depending on the individual taste of the user.

Messrs. Blackwell, who, as our readers well know, have had very large experience of overhead line work in this country, have published a list (No. 36, June, 1901), giving particulars of their standard suspensions. The hangers are made of malleable iron of the best quality, and are as light as is consistent with the necessary strength. All of these fittings are made in England, and the makers carry a large stock.

Among Messrs. Blackwell's other electric traction specialities, the "I.T.E." circuit breakers, which have been frequently described in the Review, must not be overlooked. One type is known as the laminated edgewise type, which is specially suitable for traction circuits. It is built up to 7,500 amperes' actual working capacity up to 750-volt circuits. A very long break, quick action, and extremely easy operation are the chief features. The break of the circuit takes place upon substantial carbon blocks, which are in shunt with the main contacts. A similar type of instrument is the "double pole," in which each pole is closed separately, rendering any switches in the circuit superfluous. Either or both sides will break by means of the centre operating device, so that in the event of an overload the first side will break circuit upon the closing of the second. The "I.T.E." circuit breaker is standardised in over 12,000 different types and sizes.

We illustrate a "Shaw" non-arcing lightning arrester, of which



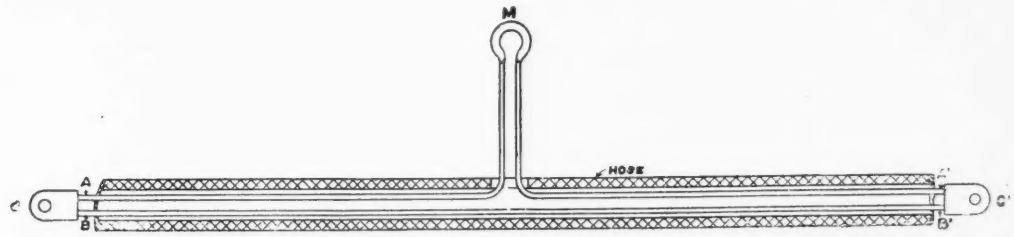
Flexible Suspensions.

there are some 20,000 in use in the United States alone. It occupies very little space and is constructionally very small and simple, and will withstand repeated lightning discharges.

The "Ajax" lightning arrester, of which thousands are in use in this country, is most convenient for section boxes, and is often mounted in a watertight cast-iron box for attachment to ordinary poles.

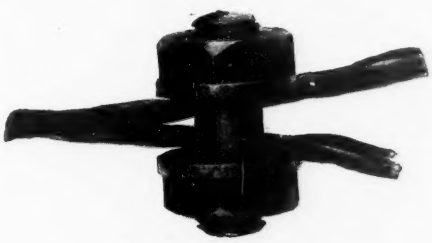
One of the illustrations on the opposite page shows a section out of a patent cable connector insulator, which has been designed for quickly connecting or disconnecting car motors. It is watertight, indestructible and inexpensive.

The "Column" type indicating and recording ammeter and voltmeter, were fully described in this journal some weeks ago. They form quite a new departure in instruments of this class, insomuch as they operate by means of compressed air which is electrically controlled. It will commend itself to engineers managing electricity works where a number of instruments are necessary, on account of the small space occupied on a switch-board; we understand that the readings are absolute, and there is no "running over." The firm also supplies a manually operated high tension oil type switch, which can also be arranged as a circuit breaker. This is built up to 200-ampere capacity for circuits up to 6,600 volts, single or polyphase systems. It is fully described in the firm's catalogue.



Controller Cable for Cars

The Christensen motor-driven air compressor has been designed to meet the special requirements of electric railway and street tramway brake service. The motor is series wound, and drives the duplex single acting compressor pistons, through double helical machine-cut steel gearing, running in an oil bath.



Guard Wire Fittings.

The various parts of the motor are so arranged with respect to one another that they occupy the minimum of space and are completely protected from injury. The motors are wound for continuous current from 100 to 600 volts, and are so proportioned that they may be run for considerable periods, greatly in excess of the requirements of brake work, without undue heating. The motor compressor is constructed in sizes having a free air capacity ranging from 7·5 cubic ft. to 47 cubic ft. per minute. A modified type is also supplied, provided with water jacketed cylinder bodies and heads, and with motors wound for continuous running.

To render the working of the motor compressors automatic an electric controller is provided, which starts and stops the compressor between any limits of pressure for which the apparatus is set. The Christensen specialities also include full air brake equipments of the "straight air," "plain automatic" and "quick-acting automatic" type, all of which apparatus has been the subject of exhaustive experiment, and is in extensive use in all parts of the world where electric railways and tramways are installed.

Messrs. Blackwell are the agents for the United Kingdom and the Colonies and various Continental countries. They have complete equipments shown in operation at their showrooms.

The Edwards Air Pump.

An important auxiliary in an electrical power station is the air pump. To procure the best working conditions for the engines such an auxiliary must be highly efficient, and to reduce maintenance charges, it should be simple and reliable in construction. In the Edwards patent pump which has been adopted for many of the leading electric traction and lighting stations in the United Kingdom, foot and bucket valves are entirely dispensed with, the only valves used being those which in the old type of air pump are known as "head valves." These valves can be readily examined and renewed through the door at the top of the pump. The condensed steam, and in the case of jet pumps, the injection water also, flows continuously by gravity from the condenser into the base of the pump. It is there dealt with mechanically by the conical bucket, which, working in conjunction with a base of similar shape, projects the water silently and without shock through the ports into the working barrel. This action is clearly illustrated in fig. 1, which is a reproduction from an instantaneous photograph of an Edwards air pump *at work*. A pump was specially constructed with glass sides to demonstrate the action of the pump in dealing with the water, and the illustration shows it very clearly.

Free air inlets are maintained, and when the water is entering the pump, instead of obstructing the passage of the air, it tends to compress the air already in the barrel and to entrain or carry in more air with it. All resistances and obstructions between the condenser and the air pump are done away with, and it thus becomes feasible to obtain a vacuum in the pump and condenser which approximates very closely indeed to the highest theoretically possible, *i.e.*, to the absolute pressure corresponding to the temperature of the air pump discharge. By the special construction of the Edwards valve seating and bucket, the top clearance is reduced to a minimum. Before an air pump can discharge, the pressure in the working barrel must slightly exceed the atmospheric pressure, consequently all air remaining in the clearance water is compressed, and on the down stroke of the bucket, this air expands and occupies space which should be available for a fresh supply of air from the condenser. With a large top clearance the greater the amount of air the pump has to deal with, the greater is the quantity retained in the clearance water, and thus it will be seen that just at the time that the pump is required to be most efficient, its effective capacity is most seriously impaired. A small top clearance is therefore highly desirable. The fact that the water is dealt with mechanically, and that its speed must correspond to the speed of the bucket renders the Edwards pump very suitable for high speeds. This has been taken advantage of by engineers, and in many cases the motors have been direct-coupled to the pump crankshaft, as shown in our description of the Pinkston Power Station.

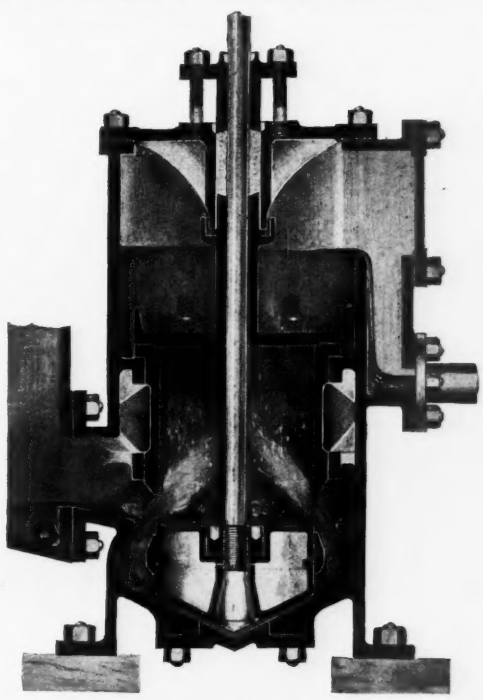


Fig. 1.

This forms a very neat and compact arrangement, but when gearing is required the motor can be arranged as shown in fig. 2. The small number and ready accessibility of the only valves used in the Edwards pump afford exceptional immunity from breakdowns, while the cost of maintenance and time necessary for overhauling are reduced to a minimum. We are informed that it is equally suitable for surface, evaporative, or jet condensing plants, and that amongst the more important installations to which it has been fitted are:—The Glasgow, Manchester, and Salford lighting and

traction stations, Newcastle-on-Tyne electric traction power house, and between 50 and 60 other electrical stations owned by various

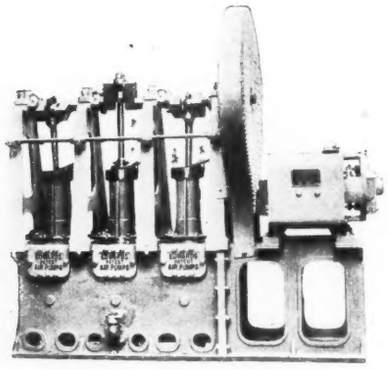
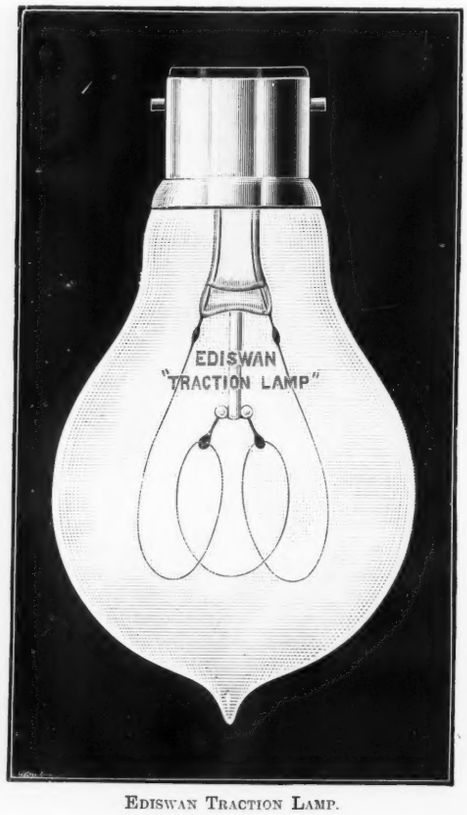


Fig. 2.

corporations and companies. The Edwards Air Pump Syndicate, Limited, has its offices at 3 and 5, Crown Court, Old Broad Street, E.C.

Traction Incandescent Lamps.

The Edison and Swan United Electric Light Company, Limited, of Queen Street, E.C., supply the Ediswan traction lamp



Ediswan Traction Lamp.

which we illustrate. The lamp is fitted with supports as shown, preventing the filament from touching the glass when the lamp is subjected to vibration. For electric tramway and railway service it is very suitable.

Tramcar Head and Roof Lights.

We illustrate in the next column Messrs. Veritys' dash-board type of electric tramcar headlight.

This fitting is strongly made, and is suitable for the hardest wear in all weathers. It consists of a heavy cast-iron bowl, which is let in flush through the front of the dash-board, only a shallow ring and the fixing lugs projecting on the face. The front is hinged for access to the interior, and is securely fastened by a hinged bolt with fly nut.

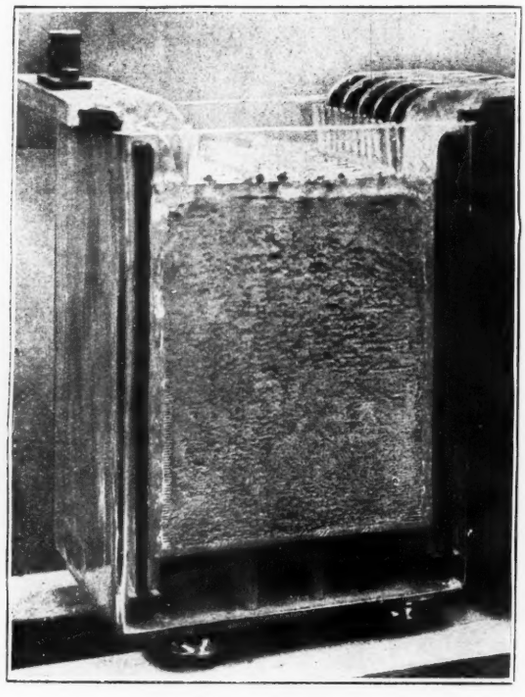
A powerful silver-plated reflector is provided, of such a shape that the cast-iron bowl has a projection at the back of only *two inches*, thus allowing the controller to be fixed in the centre of front of car instead of at the side.

Veritys' Tramcar Headlight.

A roof light for double-deck cars is also supplied. The essential features are identical with those of the headlight, but the whole is carried in two strong cast-iron supports, which are bolted on to the roof or hood of the car. This light is also supplied by Messrs. Veritys, Limited, of 31, King Street, Covent Garden.

Marquand Accumulators for Electric Traction.

These batteries are claimed to possess two special features rendering them of value for traction purposes (stationary or otherwise). First,



Marquand Storage Cell.

owing to the special formation process, positive and negative plates are produced with a surface extended far beyond the possibilities of any cast plate; consequently such plates are able to discharge at

very high rates without injury, and with a well maintained electromotive force.

The second, and perhaps even more important, feature is that with this formation process, the active materials of both positive and negative plates are in perfect chemical continuity with the lead backing, and by chemical continuity, is meant something more than electrical continuity, with the result that there is no disintegration. This important feature enables the makers, the Marquand Accumulator Company, Limited, of East Moors, Cardiff, to profitably undertake to maintain their batteries up to their specified capacity, in fact, it is claimed that depreciation, usually such a heavy item on batteries, is reduced to a figure no greater than for any other part of the plant. The very large surface for weight of lead, together with the non-disintegrating properties just described, combine to make this plate particularly suitable for motor-car or similar work.

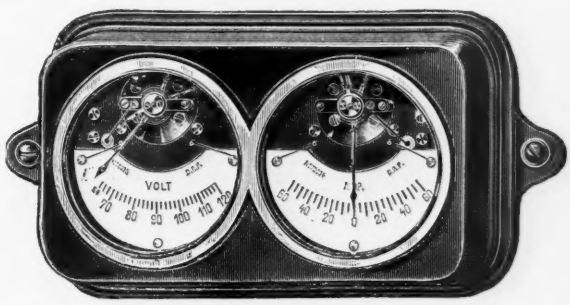
Pipes and Pumps at Salford Corporation Electricity Works.

Messrs. W. H. Bailey & Co., Limited, Albion Works, Salford, Manchester, have supplied the steam, exhaust and blow-off pipes, suction and discharge pipes for condensers, hot wells, blow-off pits and oil separators for the Salford Electric Light and Tramway Works. The steam pipes are of mild steel with welded flanges, the main steam ring being 14 in. diameter. The main exhaust pipe is 18-in. diameter, of cast-iron, with 15 in. branches to each engine. In the main steam ring are three expansion joints of copper, each bend consisting of two 10-in. copper pipes with cast-steel boxes. The steam and exhaust valves are Garvie's patent, manufactured by Messrs. Bailey, and are of the parallel face type with renewable expansion seats. On each air pump are fitted 15 in. automatic exhaust valves and 15 in. stop and back pressure valves. The air pumps and condensers are Edwards' patent; there are eight of these, one for each engine. They are of the three-throw type, each barrel being 21 in. diameter and 12 in. stroke, running at 100 r.p.m., and each is capable of dealing with 18,750 lbs. of steam per hour. Each pump is fitted with Edwards' patent air valves, which enable air to be drawn in at the proper point of the stroke. The pumps are fixed on a level above that of the discharge pipe, which is advantageous, as they can be run with the covers for access to the valves removed, so that the action can be observed. Each pump is fitted with Bailey's patent dial magazine lubricator, which provides an independently adjustable feed for each part of the pump. The pumps draw condenser water through a 20-in. suction pipe from the canal, and discharge into a 40-in. pipe, which has six outlets to the canal. Each pump is driven through double reduction gear by 50-B.H.P. electromotors, running at 600 r.p.m., constructed by Messrs. P. R. Jackson & Co., Limited, Salford. The motor and second motion shaft are carried on an extension which is bolted to the pump bedplate.

Bailey's Automatic Exhaust Valve for Condensing Plant.

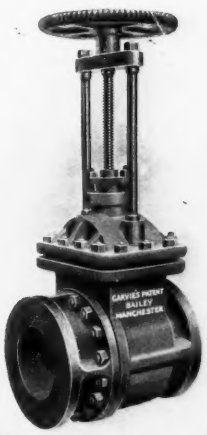
Measuring Instruments for Power Stations.

We illustrate herewith a combined ammeter and voltmeter constructed on the Deprez system, with moving coil in magnetic field of constant strength—mounted side by side in a light iron dust and damp-proof case, which shields them from disturbances by external magnetic fields. The scales are each about 2¼ in. long, and the ammeter scale is generally made with centre zero or with zero near the centre of the scale; this allows accurate readings to be taken both on charge and discharge of cells when the instrument is used on a self-propelled car. The moving parts of the instruments are light, and the instrument may therefore be fixed to the car without special mounting, and is not materially affected by vibration. It has a very small temperature coefficient, a point of considerable importance on tramcars running the whole year round, and it is dead-beat and of high accuracy. The resistances of the voltmeters are fixed inside the instrument cases, when it is not required to read above 160 volts; the shunts for the ammeter are always supplied separate, and the instrument is standardized with the shunt leads which are supplied with the instrument. The shunt itself can be fixed in any convenient position on the car, thus avoiding the necessity of bringing the mains right up to the instrument.



Berend Automobile Ampere-volt-meter.

The makers also produce an instrument made on the same principle as the combined voltmeter and ammeter, but intended for testing the individual cells of a self-propelled tramcar. The scale is about 1½ in. long, and can be supplied either with centre zero or zero on left hand of scale. The necessary resistance is fixed in the instrument case for voltmeters reading up to 60 volts. The instruments are damped by a powerful magnetic brake which renders them practically instantaneous in their readings. Messrs. O. Berend & Company, of Dunedin House, Basinghall Avenue, E.C., are supplying the above instruments.



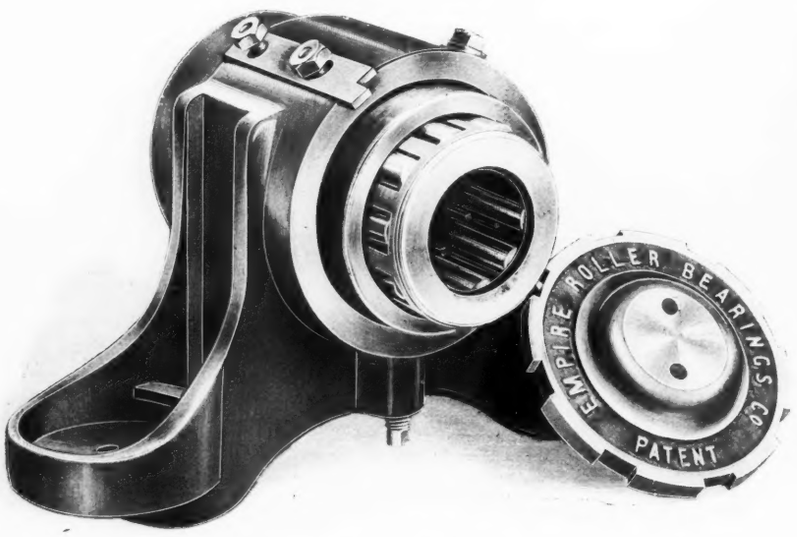
Bailey's Parallel-Slide Gate Valve for High Pressure Steam.

Roller Bearings.

The Empire Roller Bearings Company, Limited, of 1 Delahay Street, Westminster, are pretty well known among tramway authorities by reason of the extended employment of their standard roller bearings, in connection with electric tramcars and railway rolling stock. The great reduction in starting effort obtained by their use, results in a saving in coal consumption and electrical energy, and there is also said to be considerable economy in lubrication, and an absence of heating. With heavy rail vehicles the great frictional resistance experienced in starting upon ordinary bearings is reduced when upon roller-bearings to rather less than 3 lbs. per ton of load, including the wheel friction upon straight level rails. The importance of this reduction of starting and running friction is fully recognised by engineers interested in electrical traction, since the reduction of frictional resistance results in an equally great reduction in coal consumption. The bearings are constructed so as to support the load equally throughout the whole length of the rollers, with freedom from all diagonal or winding strains; consequently the parts withstand the pressure of heavy loads, and are very durable. The Empire tramway axle boxes are made suitable for journals 2½ in. and upwards in diameter, and for Brill, Peckham

and other trucks. The outer case is of cast-iron and is seated upon the centre of the bearing liner, so as to be free to move universally about the journal centre and conform to each movement of the normally vertical line of the axle-guard, or yoke, in the grooves, and of the bearing-spring bedded upon the casing. This movement of the case ensures free play for the rise and fall of the guard or yoke, in the casing grooves, and admits upon the bearing a load well balanced over the full length of the rollers and the roller-path of the journal. By this arrangement the rollers cannot take "point" load (*i.e.*, they are equally loaded throughout their length), and have no tendency to run in winding, the work of the cage is reduced to a minimum, the efficiency and durability of the whole bearing and its journal are very considerably increased, and the vibration of the vehicles very appreciably lessened by the removal of all unnecessary rigidity between the vehicle frames and the axles. On the other hand, where axle-box cases are a rigid fixture the side throw of the vehicle upon curves displaces the bearing load alternately to the back and front ends of the bearing as the curves reverse. Side deflection of springs is seriously retarded by the angling of the axle-guard until gripping occurs in the grooves of the rigid cases, and such severe leverage strains are then exerted therein as have been known to displace the bearings and jerk the springs from their seatings. At the back of the box is an oil-dressed, pliable, and durable leather guard, which effectually retains the lubricating oil, and excludes all dust or dirt.

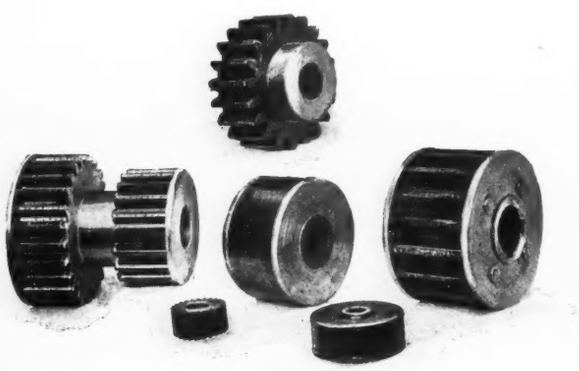
Our illustration shows one of these axle-boxes as made for Brill trucks.



Standard Axle Box for Brill Trucks.

Raw Hide Gears.

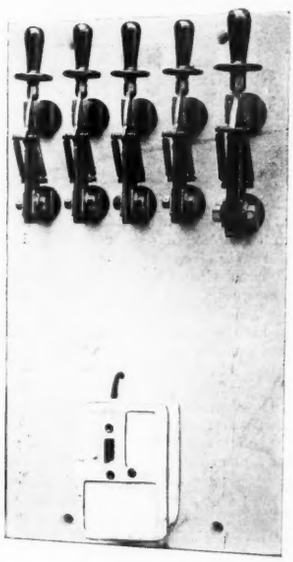
We illustrate below some of the raw hide pinions made by Messrs. W. F. Dixon & Co., of 63, Percival Street, C.-on-M., Manchester, who have lately extended their premises in order to cope with the increasing demand for their products. Messrs. Dixon and Co. make spur and bevel gear wheels of raw hide, with built-in metal bushes and flanges, raw hide mortice wheel teeth, insulators, clips, &c., for electrical installations, and machine-moulded wheels of iron, steel, and gun-metal. The raw hide gear wheels are made of all sizes up to 16 in. face and 3 ft. diameter, the hides being prepared by a novel process. The advantages of silent running and durability of raw hide gears have been fully demonstrated; and they are applicable not only to electric tramcars, but also to cranes, &c., and machine tools of all kinds. The largest raw hide gear wheel running in the Glasgow Exhibition was one of Messrs. Dixon & Co.'s, and ran throughout with entire success.



Dixon's Raw Hide Gear Wheels.

Traction Switchgear.

The Electrical Transmission Company, of Albert Works, Hammersmith, London, W., who make a speciality of the manufacture of switch gear, have specially designed and placed upon the market two distinct types of main switches for traction purposes. The firm's "T" type main switches, which are fitted with laminated copper contacts when carrying a current of more than 50 amperes, consist of two copper blades secured so that they move together, and separated by a distance piece to allow the switch lever to lie between them in the closed position, thus reducing the overall height from the slate base to a minimum. In opening the switches the lever moves through an angle of 45°, extending the springs; the blade is then, and not until then, positively forced from the contacts by the lever, and leaves the contacts with a very quick break effected by the extended springs. These switches carry no current through the hinge, so that they are "dead" in the "off" position.



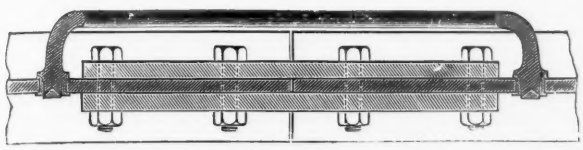
Traction Switchgear.

The figure shows a feeder pillar panel consisting of a polished marble base, having mounted upon it five of the firm's patent "L" type main switches, four for a capacity of 300 amperes, and one for a capacity of 600 amperes, also magnetic blow-out lightning arrester. Their "L" type switch is specially suitable where space is a consideration; it consists of two copper blades secured in a similar manner to their "T" type switches mentioned above, the lever lying between the blades and thus reducing the overall height to a minimum. It differs from the "T" type in that the bottom contact forms the hinge of the switch, and perfect contact at the hinge is secured by means of powerful spring washers. These switches also have a quick-break action, the lever travelling through an angle of 45° before the blade starts to move out of the contacts, and the quick-break being effected by the extended springs.

The Columbia Rail Bond.

This bond is manufactured by John A. Roeblings Sons Company, Trenton, N.J. (the English representatives being Back & Manson, 36, New Broad Street, London), and has attained wide usage on both sides of the Atlantic. It consists of three parts; two copper thimbles and the copper connecting rod. On each end of this copper rod is a truncated cone head with a fillet at the base. The inside of the thimble is tapered to fit the head of the bond, while the outside is slightly tapered in the opposite way. In applying the bond, the cone-shaped heads are placed in the holes in the rails from one side, and the thimbles are slipped over them from the other. A portable hand press is then applied, and the wedge-shaped head of the bond is forced into the thimble, so that it is not possible to see the line separating the thimble and the head in a cross-section of the two. The end of the head of the bond is expanded by a centre punch, held in position by the press. It is claimed that the Columbia consists of as few parts as any satisfactory bond can contain. When installed, owing to the pressure exerted between the head and the thimble, and also to the fact that they

are both of the same kind of metal (copper) the two become one, both electrically and mechanically. It therefore claims to possess all the advantages that may be claimed for a one-piece bond, and at the same time can be satisfactorily installed. The contact of the "Columbia" with the rail is seven times the section of the wire, providing ample contact to compensate for the poorer conductivity of the steel in the rail. The contact of rail and bond is made by a wedge expanding the thimble against the hole in the rail. This wedge is *not* driven in with a hammer as in the case of pin bonds,



Columbia Rail Bond.

but is put in with a press. A press can be so set that no matter what may be the want of intelligence or care of the workman, he cannot put in the bond in any but the right way. This is considered to be a very great point, as anyone can properly instal the "Columbia." As the "Columbia" is wedged both ways, it cannot get loose, and must make a firm contact, and cannot be over-stretched. These bonds have been used by the Corporations of Halifax, Liverpool, Brighton, Wigan, Manchester, Huddersfield, &c., as well as for the tramways of Dudley, the Potteries, Sunderland, Bristol, Middlesbrough, Stockton and Thornaby, &c.

"Buffoline" Pinions.

The illustration which we give below, is a production of a British firm, the Buffoline Noiseless Gear Company, Levenshulme, near Manchester, and shows what it can do in the way of noiseless gearing of large dimensions for heavy pump driving.

This pinion is 2 ft. 6 in. diameter by 5 in. wide, has 47 teeth, 2 in. circular pitch, and will transmit 120 B.H.P. The sole rights for the manufacture of these pinions are in the hands of the company named above.

The "Noark" Car Cut-out.

The accompanying illustration shows the "Noark" car cut-out equipment, which has been placed upon the market by Messrs. Bergtheil & Young, of 12, Camomile Street, E.C. It consists of a cast-iron box fitted with a slate base and a "Noark" fuse, an enclosed fuse which is finding favour in this country for both low and high pressure switchboards.

For the protection of car motor equipments these fuses are claimed to not only ensure an accurate, safe and definitely adjusted cut-out for the motor, but they also permit the conductor or motorman to replace a blown fuse in a fraction of the time now necessary. They do not frighten passengers or adjacent pedestrians or horses by a fireworks display. They not only protect the car motor, lighting or heating equipment, but are also suitable for all motor service.

Owing to the time interval overload operation, "Noark" fuses of smaller current capacity than the open fuses used on car equipments can be used with even less frequent blowing and better protection to the apparatus.

An important feature to note is that the fuses are rated at their maximum definite current-carrying capacity. They will operate at this current continuously without rupture, and every attempt is made to make this rating as accurate as practical refinement will allow. Excess current above this rating will blow the fuse in a time interval depending inversely on the overload.

"Noark" Car Cut-out.

The fuses may in very many cases entirely take the place of automatic cut-outs, and are certain in their action and safe, since a starting current rush or sudden overload of short duration does not result in injury to the motor if the latter is properly protected.

The fuses have a definite and accurate time interval of operation, ranging from minutes on small overloads, to the infinitesimal part of a second on heavy overloads, and operate instantaneously on short circuit.

Newcastle Tramways.

The Newcastle Corporation is at the present moment actively engaged upon the work of constructing its extensive electric trolley system of tramways. We may mention that the whole of the

B.I.W. Section Panel.

feeders, amounting in all to 20,000 yards of 75 single plain lead-covered cable, have been drawn in and jointed by the British Insulated Wire Company, of Prescot, in conduits laid by the Corporation. The cables are of B.I.W. ordinary type, insulated with resin oil impregnated paper, for traction work, the lead of the cables being, of course, suitably earthed at various points to

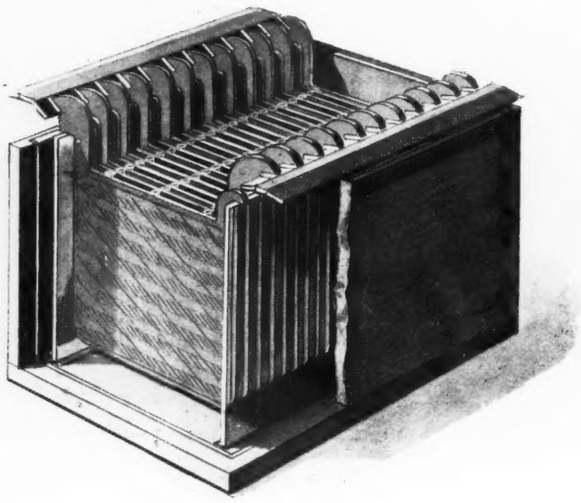
prevent any damage from electrolysis. The overhead work consists of the equipment of about 15 miles run of road. The whole of the poles and brackets are being supplied by the Corporation, but erected by the B.I.W. Co.

The company are also providing all the overhead fittings and 4 trolley wire, and section pillars. These pillars are of their standard type, and they have done a considerable business in them since they made a speciality of them a few years ago.

The accompanying illustration shows the type of section panel which is to do service at Newcastle.

Batteries for Tramway Power Stations.

The Hart Accumulator Company, Limited, have lately supplied several large tramway power stations with their make of storage batteries. The type of cell is shown below. The plates are



Hart Storage Cell.

specially designed and constructed to withstand heavy discharge rates, and the cells can be supplied to give any required capacity. The containing boxes are usually made of hard wood, so treated as to withstand the action of sulphuric acid, and lined with lead, and all connections are entirely non-corrosive, so that no trouble can arise from this source. The Hart Company have supplied similar cells for this class of work contained in glass boxes, these plates being constructed on exactly the same principle, although of a smaller size.

Pitkin's Station Instruments.

Mr. James Pitkin, of 56, Red Lion Street, Clerkenwell, E.C., is well-known as a manufacturer of electrical measuring and other instruments. It was for him that Major Holden designed his patent hot-wire recorders, which are in extensive use both at home and abroad. These recorders were followed by other forms as the need

Pitkin Moving-Coil Ammeter.

or such arose, and Pitkin's permanent magnet moving coil type of recorder is specially adapted for use in a power station on the Board of Trade switchboard panel. The illustration which we give is of the firm's permanent magnet moving coil ammeter.

Tramcar Motors.

We illustrate herewith the standard traction motor built by the Lahmeyer Electrical Company, Limited, of 109—111, New Oxford Street, London. Figs. 1 and 2 show the complete motor and gear closed, and fig. 3 shows the motor alone with the case open. The design is specially arranged so as to afford ready access to all parts; for instance, either of the bearings can be removed by loosening two bolts, without opening the frame; the frame itself, and the gear-casing, are also opened with ease and celerity. By means of holes bored into the ends of the motor, which are usually closed with bolts, it is possible to see through the air-gap between the

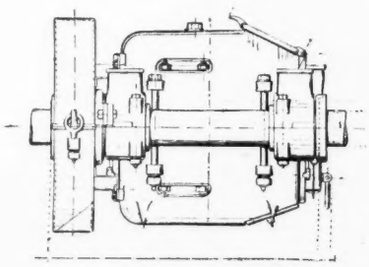


Fig. 1.

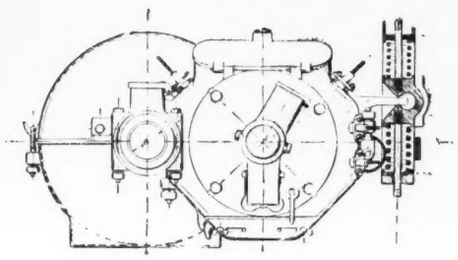


Fig. 2.

poles and the armature core, in order to ascertain whether the brasses are worn so much as to render new ones necessary. The armature coils are wound on formers and are insulated by special

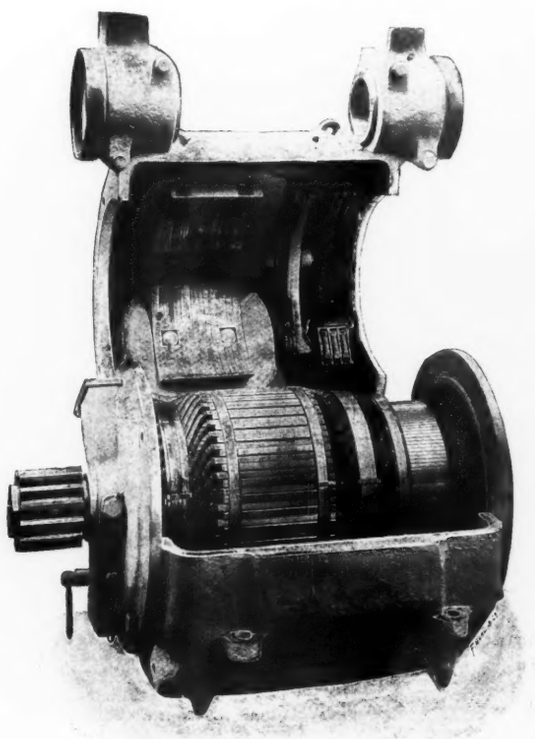
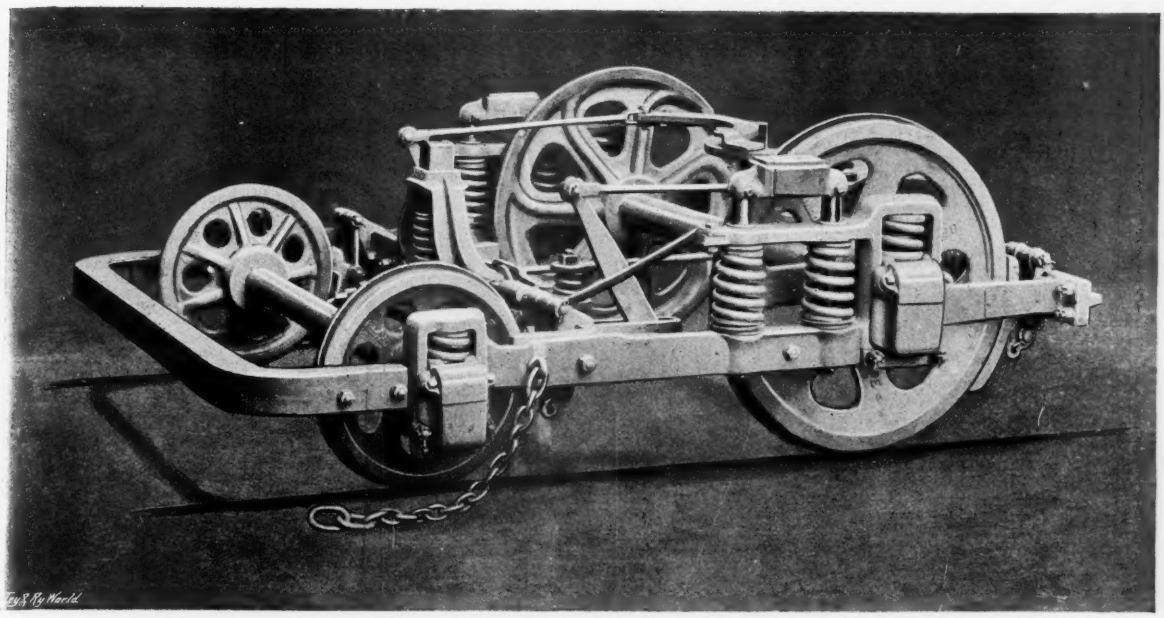


Fig. 3.—Lahmeyer Motor with Case Open.

machinery; they are readily interchangeable, as also are all other parts of the motor. The air-gap in these machines is kept large,

so as to diminish the risk of contact between the armature and pole-pieces; the efficiency, however, is good, and the motor is capable of withstanding an overload of 20 per cent. without sparking.

Royle's evaporators, condensers, calorifiers, and other auxiliary steam plant for electric power stations. They also manufacture steam traps, reducing valves, steam dryers, and many other steam fittings.

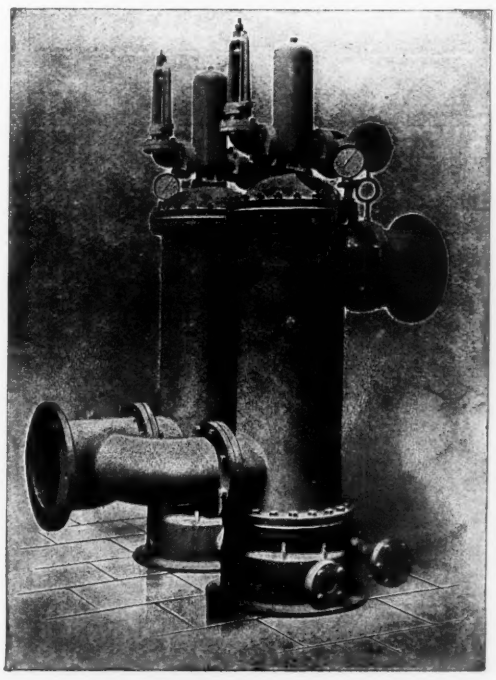


Brill Maximum Traction Truck.

Royle's Feed Water Heaters.

A speciality of Messrs. Royle's, Limited, of Dalham Engineering Works, Great Bridgewater Street, Manchester, is their Row's patent feed water heater, of which we give a view, showing the latest type

The "Row" tube is the fundamental feature of the apparatus. The tube is indented, producing a thorough break up of any fluids passing over the surface, and experience is said to prove that such indentation increases the efficiency to double that of plain



Royle's Feed-Water Heater.

tube. At the same time the longitudinal rigidity of the tube is destroyed—the indentation rendering it quite elastic, so that it can be fixed between tube plates without fear of fracture from expansion or contraction. The tubes are formed from solid drawn copper of the best quality, and are carefully tested before being made up.

The feed heater of the type shown is made in many sizes from 20 to 2,000 I.H.P. Its main purpose is to economise exhaust steam, and impart a high temperature to boiler feed, economising the fuel bill by 15 to 20 per cent. The "Row" tubes are also fitted to

Brill Tramcar Trucks.

One of the latest improvements in connection with motor trucks for electric tramcars and railways is the substitution of solid *forged* side-bars in all the different types of trucks manufactured by the J. G Brill Company (Mr. Mackell E. Curwen, 110, Cannon Street, E.C., European manager) Brills have for several years used a solid forged side-bar on their electric motor truck for four-wheel electric tramcars, but it has only been within the last few months that they have been able to perfect the necessary machinery to enable them to manufacture the side-bars for all their bogie trucks of solid forgings. They have now reached a point where they are in a position not only to supply solid forged side-bars to all types of their trucks, but at what is considered a reasonable price.

Heretofore there has been more or less objection against cast steel side-bars, or side frames, on account of the possibility of blow holes or sand holes in the castings. With forged side-frames, we understand that the possibility of danger is eliminated, and furthermore, the forgings are mostly much smoother than castings in steel

Our illustration shows a maximum traction truck with solid forged side-bars.

It is necessary to point out that the angle iron cross-bar at the back of the small wheels does not pertain to the truck proper, but on the particular contract to which this truck applies the angle-iron was used in connection with air-brake equipment.

The "Protected" Rail Bond.

This rail bond is manufactured and sold by the Forest City Electric Company, 18, Piccadilly, Manchester, who have made a special study of the problem of rail bonding, and who undertake the design and manufacture of bonds to suit all cases and conditions. Their bonds generally consist of a flexible copper conductor, fused to solid copper terminals. The flexible part of the bond is

"Protected" Rail Bond.

composed of a number of specially drawn flat copper strips, the cross-sectional dimensions of which are ·193 × ·036 in., placed parallel to each other, and in such a position in relation to the rail that any bending or vibration to which it may be subjected, due to any movement at the joint, will be in the direction of the least dimension of the strip. This construction makes an extremely elastic bond, and any distortion to which the bond may be subjected will generally be within the elastic limit of the copper. This also means a minimum amount of strain on the terminals, which is c

vital importance. Crimps, or loops, are formed in the flexible part of the bond to provide for contraction or expansion of the rail. These may be inserted in any portion of the bond, varying according to the position of the bolt holes in the rail, and the position of the other bond, in case of double bonding. The bonds are fastened to the rail by expanding the solid terminals in the holes by specially-designed machinery, by which extreme pressure the copper is made to flow into every minute irregularity of the hole, and a perfect mechanical, as well as electrical, joint is attained. The manufacturers of this bond recommend the use of a short bond placed under the fish-plate, thereby utilising as much of the rail as possible as a conductor, and economising copper, as well as reducing the total resistance of the joint. We understand that the Vicinaux tramways of Brussels so far recognised the advantages of this method of bonding, that they changed the design of their fish-plate, and had the same re-rolled to have the requisite space between the plate and the web for a short bond. The form of the flexible conductor is such that the greatest amount of copper, in the most desirable form, can be introduced into the space between the fish-plate and the web. The company also manufacture long, solid, and cable bonds for cross bonding, and as conductors between the rail and the return wire, when such is used. Their method of attaching a solid terminal to a flexible cable by fusing the terminal to the conductor, and at the same time throwing out a protecting sleeve along and around the cable, is a speciality which we are given to understand has obtained for them some of the largest contracts for bonds ever given out.

Fowler Switchboard for Leeds Tramways.

Tramway Switchboard at Leeds.

The accompanying engraving illustrates the Leeds Tramway Switchboard constructed by Messrs. John Fowler & Co. (Leeds), Limited. It consists of enamelled slate bases mounted on iron framework, to which the various instruments are fixed. The main switches are of the firm's lever shutter type with carbon breaks. The fuses which are fixed on the return feeders are protected from spluttering by means of Hall-Fuller patent asbestos sheathing; the automatic cut-outs being placed in circuit with the positive feeders. The board is constructed for controlling five generators of 800-kw. capacity, 21 positive feeders and 22 negative feeders.

Escher-Wyss Turbines in Traction Stations.

At the electricity works at Bex (Ct. de Vaud, Switzerland) the plant installed includes six Escher, Wyss & Co.'s patent Pelton turbines, each developing 400 b.h.p. under a fall of 160 metres (= 525 ft.). The dynamos are direct coupled to the turbine shafts, which run at 600 r.p.m. The plant supplies (1) the electric light for Bex and surrounding villages, with a large number of hotels; (2) power for a number of small industrial works in the neighbourhood; (3) power for an electric tramway of 20 miles

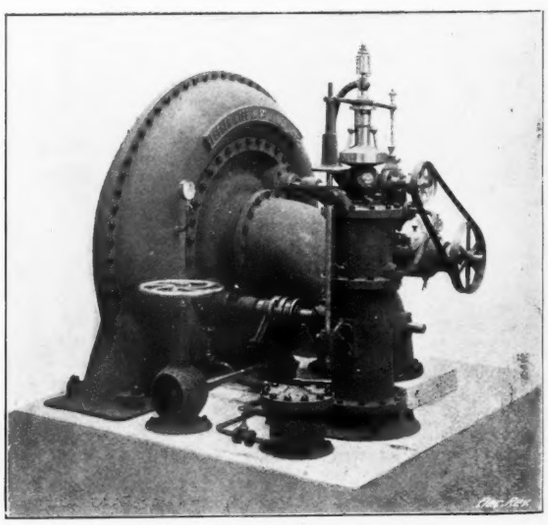


Fig. 1.—Escher-Wyss Pelton Turbine.

length and a mountain railway about five miles long. The turbines, of which we give an illustration in fig. 1, are supplied with patent

hydraulic governors, which are capable of keeping the speed constant within about 5 per cent. on sudden changes from full load to no load, or *vice versâ*.

In fig. 2 we show a plant supplied by the same makers in connection with the Jungfrau Railway. The installation at the power station

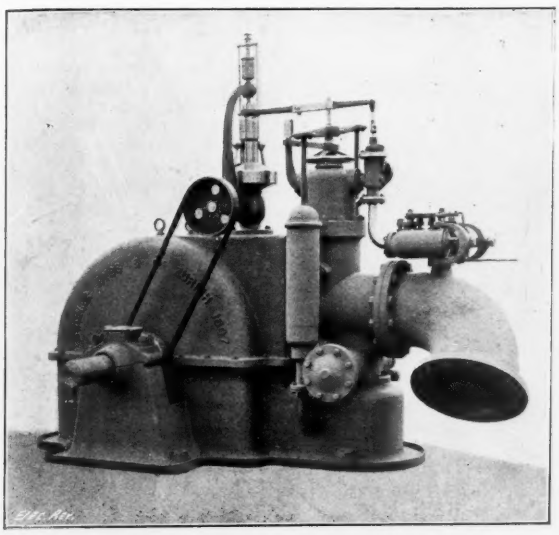


Fig. 2.—Jungfrau Railway Turbine.

at Lauterbrunnen consists of two Escher-Wyss central-flow reaction turbines with horizontal shafts, each giving 800 B.H.P. under a fall of 32·5 metres (= 106 ft.), running the direct coupled dynamos at a speed of 380 r.p.m. The couplings invariably used are Lodel's patent flexible insulating couplings. Fig. 3 is a representation of the sets employed by the Société des Foues Motrices et Usines Electriques de Vézère (France). The plant consists of four Escher-Wyss & Co.'s central flow Beaulieu turbines with horizontal shafts, each turbine giving 600 B.H.P. under a net fall of 43 metres

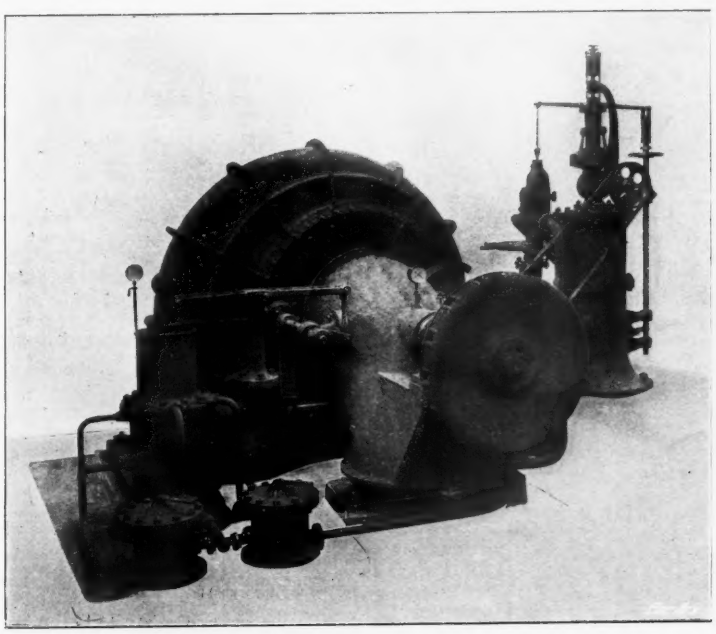


Fig. 3.—Escher-Wyss Beaulieu Turbine.

(= 140 ft.), besides which there are two separate turbines of 100 B.H.P. each, driving the exciters. The power is mostly used for running tramways connecting neighbouring towns. Mr. Alph. Steiger, M.I.C.E., of 28, Victoria Street, S.W., is the sole representative in this country for Messrs. Escher, Wyss & Co.

Safety Devices for Trolley Lines.

The British Insulated Wire Company, of Prescot, are the manufacturers of an automatic cut-out and pillar, for use as a safety device in the case of the trolley wire breaking. The apparatus consists of four switches fixed in each pillar. Each of these is a double-break switch, and has a main coil in series with it, and it is so arranged that should the current through this coil exceed, say, 200 amperes, or whatever current it was adjusted for, the plunger would be drawn up against two catches, which release the switch, so that in case of any short-circuit or excessive current, the line is automatically cut out.

At the back of the switch there is a shunt coil, which is connected by a pilot wire that may either be run overhead on insulators fixed to the bracket arms, in which case it must be protected by guard wires; or it may be run as an insulated conductor underground, with the test wires, to the end of the section, where it is connected to the overhead wires; this coil, at 500 volts, holds up the plunger that works inside it, and is so arranged that if the line were to break, the pressure would, of course, be cut off from the pilot wire, and therefore from the shunt coil, releasing the plunger, which falls on two catches and releases the switch, automatically cutting off the rest of the circuit. These pillars are fixed every mile, or every half-mile, and if they are arranged with four switches in each pillar, two feeding each way on to the trolley lines, there will be a section insulator halfway between the two pillars.

Overhead Line Equipment.

In fig. 1 we show the Globe standard strain insulator, and in fig. 2 a Brooklyn pattern insulated turnbuckle as supplied by the General Electric Company (1900), Limited, of Queen Victoria Street, E.C. The insulation material employed in the manufacture of these standard strain insulators is the same as the company has been selling for years in this country, and is claimed to be especially durable and efficient, giving excellent results under all conditions. A series of tests made as to electrical resistance and mechanical strength shows that an E.M.F. of 16,000 volts was applied without the insulation breaking down; a temperature of 270° F. was reached without any effect, and above that temperature the material gradually softened. The "Globe" insulators were subjected to heavy pressures with most satisfactory results, and the material is claimed to be far stronger electrically and mechanically than is necessary, even after allowing a large margin for safety.

In fig. 3 we illustrate a three-way frog for use in connection with swivel trolley heads, this being made under Wood's patents. The G.E.C. switches, or points, provide a continuous path or guide from which it is impossible for the trolley wheel to diverge. This is effected by means of the periphery of the wheel being compelled to run in the grooves, which are suitably arranged in a manner somewhat similar to that of the car wheels in the rails.

Wood's patent swivel trolley head is seen in fig. 4. Among the improvements which it embodies is a self-oiling arrangement con-

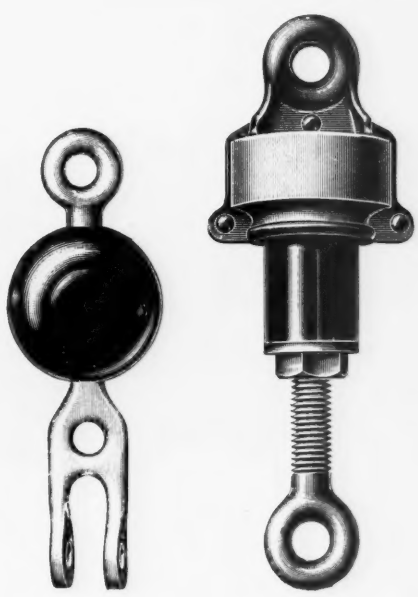


Fig. 1. Fig. 2.

sisting of a hardened hollow steel spindle with a slot cut through on the bottom. The spindle is filled with grease and is claimed to be able to run for six weeks without attention.

The "Wood" head is said to be the one which has first run with the rope tied up to the pole in Great Britain or America, and during the five years it has been in continual use on some of the largest systems there has been no accident. The method of insulation is considered to provide absolute security. It is formed in one piece, and can be readily fixed by unskilled labour. The weight of the head is reduced to a minimum; the bearing surfaces are the largest obtainable, and are provided with an adjustment which can be regulated to $\frac{1}{10}$th of an inch. The thrust from the wire is taken on a ball bearing, an arrangement which has been found necessary to all swivelling trolley heads.

Among the other electric traction specialities of this company are gears and pinions for motors. The gears are open hearth cast-steel cut motor gears, and the process of manufacture and material employed are such that mechanically correct teeth are ensured. All gears contain eight bolts with lock washers and cotter pins, provision being also made to prevent the head of the bolt from turning. Another G.E.C. detail is

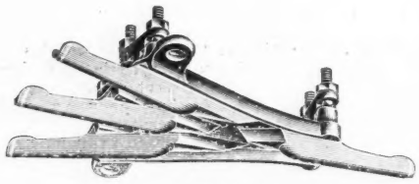


Fig. 3.

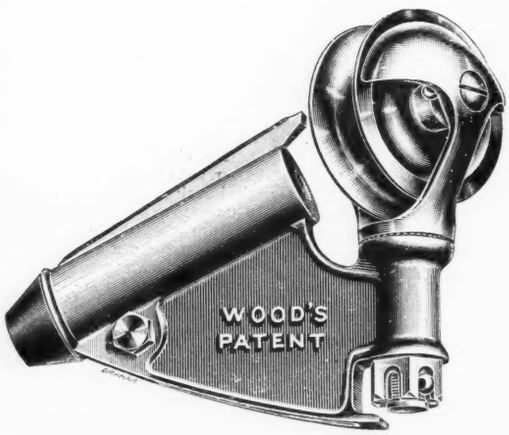


Fig. 4.

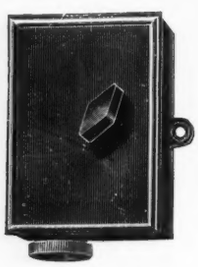


Fig. 5.

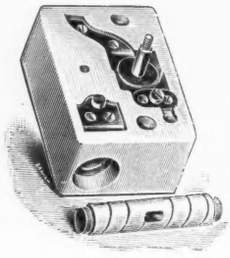


Fig. 6.

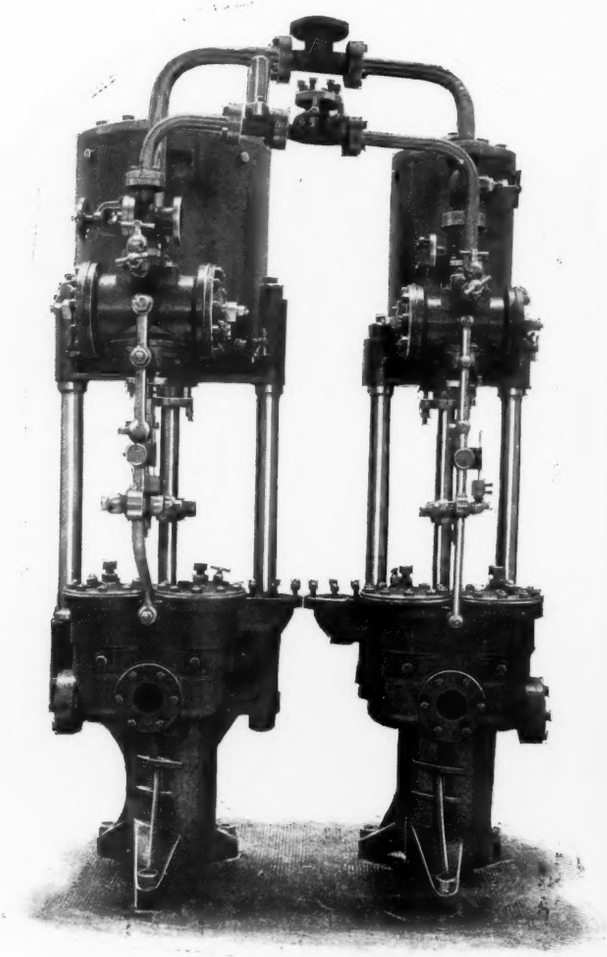
the car lighting switch with fuse (figs. 5 and 6). The switch is substantial in form, and is fitted with a porcelain plug to take the fuse wire, held in place by a spring contact. The whole is enclosed in a strong and neat iron case. Fig. 6 shows the porcelain inside and fuse plug.

Rail Bond Testing.

Messrs. Kelvin & James White, Limited, of 66, Victoria Street, S.W., and Glasgow, whose insulation testing sets are so well known, have lately put on the market another compact testing set for use in testing rail bonds. It consists of a very sensitive low reading voltmeter, mounted in a box with a two-way switch. This switch is connected to adjustable contacts mounted on a graduated bar of suitable length and compact form, so that the contacts can be pressed on the rail by one hand, and the readings noted on the lid of the box, which forms a desk, the box itself being carried by a strap round the neck of the linesman. The method of using this instrument is as follows:—The two contacts on the graduated bar are put across the bond to be tested, the other two contacts resting on the rail. The voltmeter switch is put to the "rail" contact, and the deflection noted. The switch is then put to the "bond" contact, and deflection noted. The deflections being proportional, the resistance of the bond is therefore known. The instrument itself has two ranges, giving a total range of 0·0005 volt to 1 volt. It has supplied a long-felt want, and traction engineers would do well to adopt it as a means for testing faulty bonds. Lord Kelvin's instruments are so well known, being described fully in our issue of November 15th, that it is needless to give details of these. We would, however, refer traction engineers to the S.R. (syphon recorder), or shunted type ammeter, made by this firm, which is specially suited for traction and for the measurement of large currents. These instruments are made in three different forms, the "round," the "thistle," and the "edgewise."

Weir's Feed Pumps.

The feed pump is an important item in the auxiliaries of the boiler or steam plant; Messrs. G. and J. Weir, of Cathcart, Glasgow, have for years been identified with boiler feeding specialities, and we believe that they have done much to teach electrical engineers the value of a reliable slow-speed boiler feed pump. The Weir



Weir Feed Pumps.

single pump is no steam-eater, for not only does it cut off before the end of the stroke and thus secure economy, but the workmanship is such that a very high mechanical efficiency is obtainable for long periods. The Weir standard feed pump has been so widely taken up for power stations that it is unnecessary to describe it in detail. We have, however, been furnished by Messrs. Weir with particulars of their latest twin compound feed pump arrangement, which has been devised with a view of attaining still further economy. The plant consists of two Weir single pumps placed side by side, one pump having the high-pressure cylinder and the other the low-pressure cylinder. Each pump is independent of the other as regards working, so that when the load is light and only a small amount of boiler power is wanted, only one pump need be run. When more boiler power is required, the second pump can then be put on and can be coupled up so that the exhaust from the first is led into the cylinder of the second pump, and the advantage of compounding is attained with a full load. The pumps are usually run at the normal speed of 12 double strokes per minute, but should occasion demand it, they can easily be run at a considerably higher speed in order to make up any deficiency in the boiler feed supply. We learn that a number of tests were made on the steam consumption of these twin compound pumps delivered by Messrs. Weir to the Corporation of Glasgow Electric Tramway Department, with the following results:—

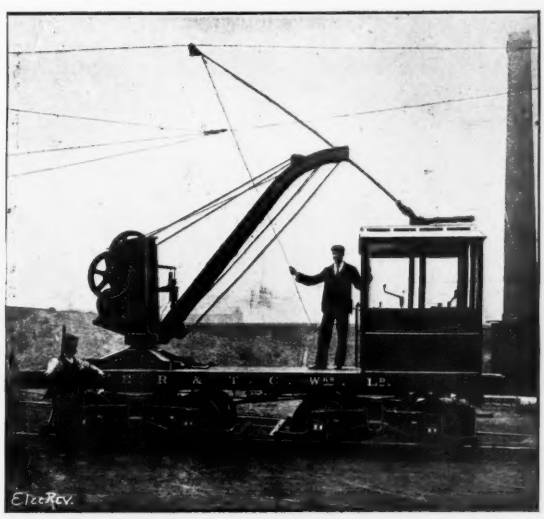
Size of pump.		Water pressure.	Double strokes per min.	Efficiency of water end.	Pounds of water delivered per pound of steam used.
Diameter	Stroke p.m.				
9½	21	190	12	96·3	147·7

It will be seen, therefore, that this installation leaves little to be desired in the matter of economy. Messrs. Weir have now standardised these pumps in a similar fashion to their standard single pumps, and no doubt there will be a good demand for them.

A further modification, which is somewhat of a novelty, is secured by Messrs. Weir's triple-compound feed pump arrangement; it consists of three simple direct-acting pumps of the Weir type, connected up in such a way, that any one of the three pumps may be used independently, or the three pumps may be used together on the compound principle, the cylinder of the middle pump serving as the H.P., and the two end ones as the L.P. stage of expansion in a compound cycle. As in the ordinary single pump, also, the steam may be used expansively in any or all of the cylinders, thus serving the double purpose of enhancing the economy, and slowing down the pump at the end of the stroke. For large traction stations with varying loads, the above arrangement is specially recommended. For special plants where, from necessities of space, the twin compound is not suitable, Messrs. Weir also supply their tandem compound feed pumps, in which the H.P. cylinder is set above the L.P. cylinder, both cylinders taking their steam through a cylinder valve. The feature of Messrs. Weir's design is, that no leakage can possibly pass from the H.P. to the L.P. cylinder, as is usually the case where cylinders are fitted close together. We understand that Messrs. Weir have also supplied a large number of pumps for light duty, and tank and cooling tower purposes.

Travelling Cranes in Tramway Works.

As showing the adaptability of an electric tramway or railway system for various operations, we illustrate a special type of travelling crane which has been evolved at the Electric Railway and



Electric Travelling Crane.

Tramway Carriage Works, Preston, for work on tramways, railways or in engineering yards. There is no doubt that the type illustrated should have a considerable application under many conditions.

Calcutta Electric Tramways.

An important contract at present being carried out by Messrs. Dick, Kerr & Co., Limited, is the Calcutta tramways, and in connection with the permanent way, we reproduce an example of the special work of the track on this system, the illustration showing the fan at the car sheds. It may be observed that this has been made at the Kilmarnock works of Messrs. Dick, Kerr and Co., Limited.

The work carried out covers the erection of the power house and complete equipment of the line, which comprises about 18 miles of tramway route.

The power house equipment comprises three main engine and dynamo units, each developing 675 I.H.P. under normal conditions. They are, however, designed to work up to 950 I.H.P., which is 25 per cent. overload.

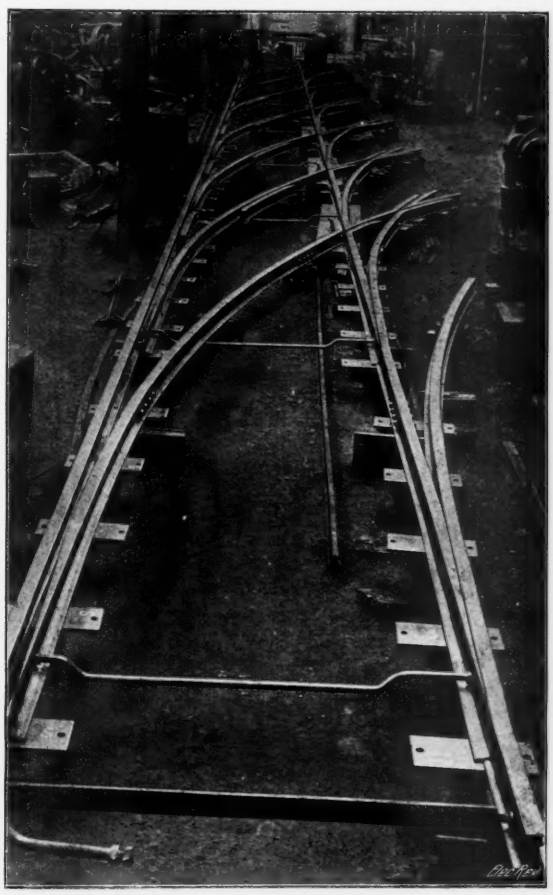
The engines are of the horizontal cross-compound type, working condensing. They have cylinders of 21 in. and 40 in. diameter, and 3 ft. 6 in. stroke, and run at 90 revolutions per minute. They are made by Messrs. Yates and Thom, of Blackburn.

The fly-wheel is 16 ft. 6 in. in diameter, and is constructed in sections, and weighs about 29 tons.

The generators are of the multipolar type, with inwardly projecting poles; the frame is arranged for sliding along girders sufficiently to uncover the armature.

The magnet poles are of laminated steel, cast into the magnet yoke, which is of special quality cast-iron.

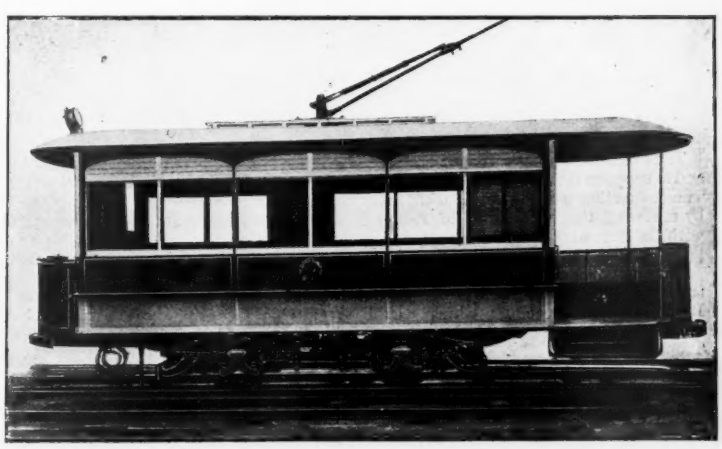
The machines are compound wound, the series and shunt windings being arranged as distinct coils side by side on one spool. In all other respects the machines are similar to those generally supplied by Messrs. Dick, Kerr & Co., Limited, and made by the English Electric Manufacturing Company, Limited.



Calcutta Car Depot Fan.

There is a small supplementary unit, consisting of a horizontal tandem compound non-condensing engine and a dynamo, with a capacity of 150 KW., the engine being of the Robb & Armstrong type, and the generator similar to those previously described.

There is a complete equipment of surface condensing apparatus, with the necessary air and circulating pumps. Klein's cooling towers, with fan draught, are also provided.



Calcutta Tram Car.

The steam-raising plant consists of six Galloway boilers. Green's economisers, consisting of 480 tubes, have been supplied, and two Weir's direct-acting feed pumps.

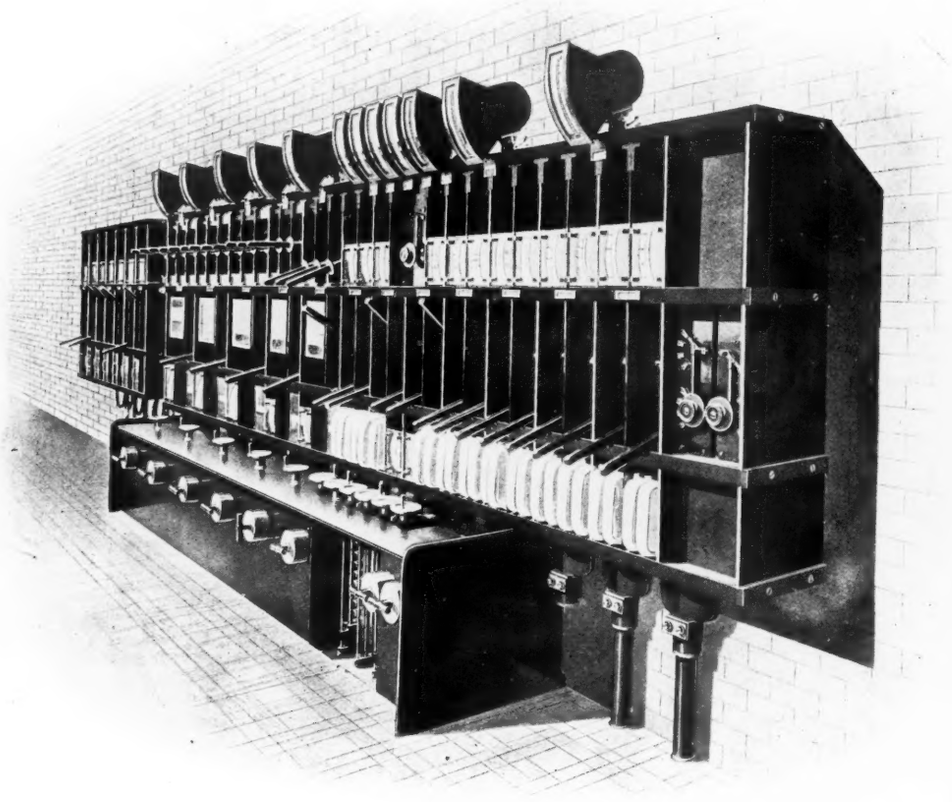
As giving an idea of the magnitude of the system, it may

observed that the rolling stock comprises 100 cars, 50 being provided with sashes for protection against inclement weather. The remaining 50 are provided with the usual glass windows. The former type is shown in the illustration. It is proposed to augment the system by 100 trailer cars.

The following is a general specification of the closed type of single-deck motor cars supplied to Calcutta:—Length of body, 17 ft. 3 in.; length over both platforms, 25 ft. 3 in.; total length overall, 26 ft. 3 in. The seating capacity is 27 passengers. The floor frames are built of well-seasoned teak, and the usual openings are arranged in the frames to afford convenient access to the motors. The platform floor frames project out from the front end to provide sufficient room for brake gear, controller, and motorman, while at the rear they project sufficiently to allow for a seat on one side and the ordinary entrance.

The specification for the open type car provides for the length over corner posts of 20 ft. 6 in.; length over both platforms, 25 ft. 3 in.; total length overall, 26 ft. 3 in. The materials and construction generally are similar to the closed car.

The trucks are of the Brill 21 E. type, having a wheel base of 6 ft. and a length of spring base 14 ft. 6 in. The equipment consists of two 25-H.P. motors, and there are the usual controllers, switches, &c. The trolley is provided with a swivelling head, suitable for the side suspension system.



Ferranti Traction and Lighting Switchboard.

The overhead trolley wire is of hard drawn copper, No. 000 S.W.G., and is supported throughout by means of double insulating hangers. The connection is made between the feeders and the overhead wire by means of the usual form of feeder pillars, which are provided with the necessary switches for making proper connection, and with lightning arresters.

The foregoing example gives an idea of the modifications of the tramcar rendered necessary by variations of climatic conditions. It is clear that the car which would be suitable for ordinary English conditions would be utterly unfitted for work in the Tropics.

Continuous Current Combined Traction and Lighting Switchgear.

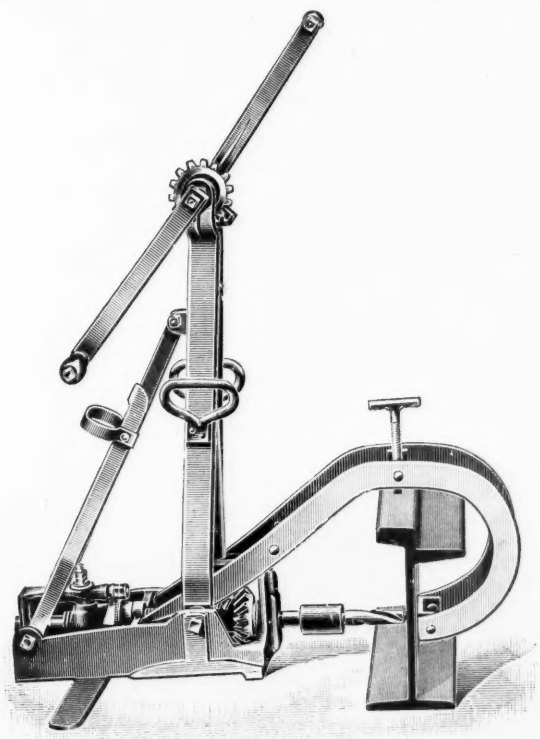
The design of switching apparatus has received more skilled attention recently than in previous years. The change has, undoubtedly, been brought about by smaller troubles and difficulties caused by unsatisfactory switchboard constructions. The existence of this trouble is not surprising when one considers that the switchboard is the part of the central station where all connections of the system are concentrated into a confined space. The old principle of mounting fittings and switches indiscriminately on the surface of a flat slate and connecting up by inflammable cables at the back is fast disappearing. In place of this type of board we see arrangements forging ahead in which greater attention has been paid to design. Fire risks are minimised by avoiding the use of inflammable materials and by the provision of an improved arrangement of connections. In all possible cases the numbers of connections are reduced by carefully fixing the positions of the various apparatus used on the board, also cross-connections and long leads are avoided.

The Ferranti type of switchboard is universally known for high tension work, and it is eminently satisfactory to know that continuous current switchboards for lighting and tramway work are now constructed on the same principles. We reproduce an illustration of one of these switchgears. This gear is used for a combined 460 volts lighting and 500 volts traction system. The lighting feeder panels are shown on the extreme right of the switchboard, each three-wire feeder panel consisting of two ammeters, two single-pole switches, and two sets of oil break fuses. Two pilot voltmeters are mounted on the top slate and coupled up to the voltmeter switches on the end panels to the right. There are four lighting feeder panels, each suitable for carrying 500 amps. The switchgear for battery, booster and balancers used on the lighting system is mounted to the left of the feeders, between them and the dynamo panel. The battery regulating switch will be seen under the regulating table in front of the board. We next come to five generator panels, which can be distinguished by the five watt-hour-meters mounted in a line with the quick-break switches. Each of these generator panels contains (*a*) three-pole change-over switch, by which any generator can be coupled to either the traction or lighting bus bars, (*b*) the watt-hour-meter before mentioned, (*c*) ammeter in panels below watt-hour-meter, (*d*) a quick-break switch which is operated by an automatic device fixed in the recess under the switch. This automatic device is designed to open the machine circuit on reversal of current or when an overload current passes through the circuit. Edgewise voltmeters of Evershed's make are mounted on the top slate over each panel.

The regulating table in the front contains a switch in the field circuit of the dynamos and a handwheel for regulating the pressure across the terminals of the machine, the resistances being of the Ferranti open type, mounted underneath the switchboard platform.

The traction feeder panels are at the extreme left of the board. The illustration shows seven of them, each capable of carrying a working current of 500 amps. These traction panels are similar in construction to the rest of the board, each panel containing (1) edgewise ammeter, (2) quick-break switch, (3) automatic device

below the switch to open circuit when the current reaches a predetermined overload, (4) lightning arrester and kicking coil.



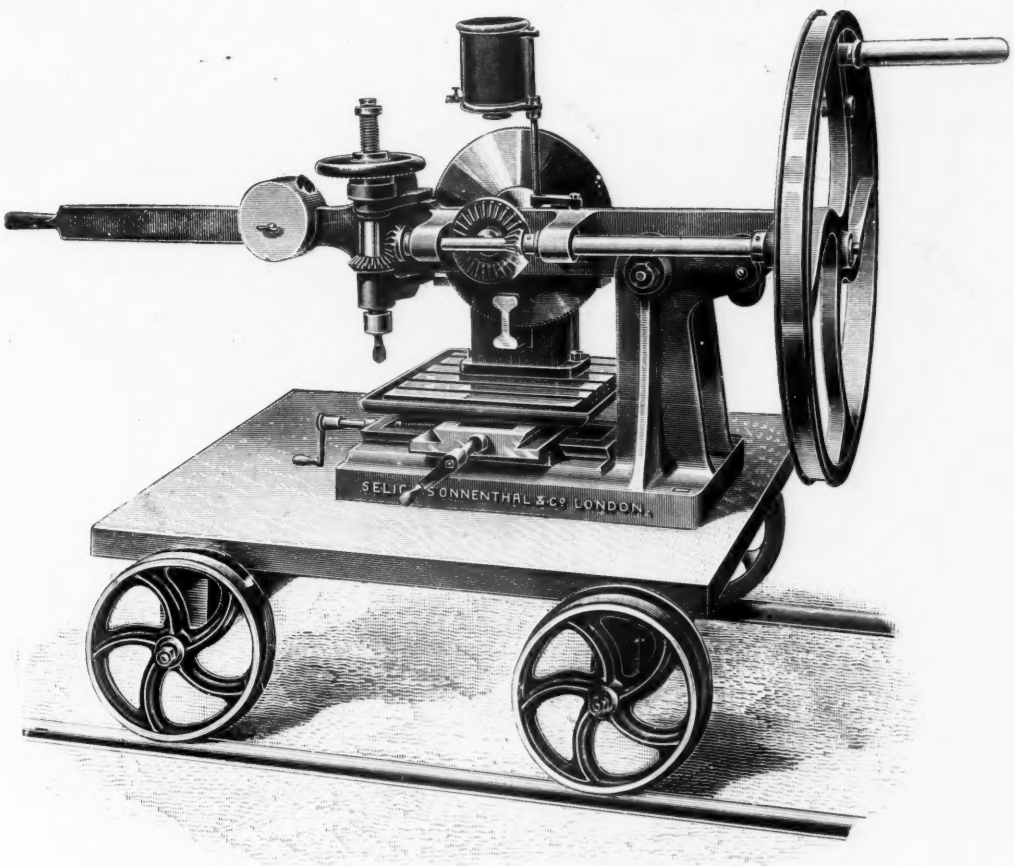
Tram Rail Track Drill.

have this type of switchboard in hand for a number of places, and no doubt it will become widely used for continuous current work, and be as successful as their H.T. switchboards have been. The great advantages of the design are, obviously—(1) mechanical design and construction; (2) minimum fire risks; (3) greater security to operators and less chance of dangerous shocks or burns; (4) simplicity of construction, thus reducing the possibilities of errors in manipulation; (5) no back or entanglement of cable; (6) all connections are mechanical and visible from the front, so that they can be easily traced.

Tramway Track Drills.

Messrs. Selig, Sonnenthal & Co., of 85, Queen Victoria Street, E.C., are the agents for the Sundale circular cold sawing machine for hand power, the portable type of which is specially intended for railway use. This machine, which we illustrate below, is worked by hand power, and is intended for cutting iron or steel rails, joists, &c. It is a useful tool for cutting rails at stations or along the line where new rails are being laid, for cutting fitting pieces to length, and it may also be advantageously used on lines under traffic. It has a clean and accurate cut, and effects a saving in time. The amount of feed is regulated by mechanical means, and adjusts itself automatically to the work by means of a weighted lever, feeding the saw quicker to its work where the section is small, and reducing the amount of feed in larger sections. One man can cut an ordinary cast-steel rail in about 15 minutes, and ordinary iron rails in less time; a 10-in. girder in about 12 minutes; L iron $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{2}$ in. in about $3\frac{1}{2}$ minutes, &c. The machine will cut round iron or steel up to 5 in. diameter, and girders up to 10 in. deep. A removable drilling arrangement can be fitted to the machine; we understand that it will drill a fish-plate hole in about $2\frac{1}{2}$ minutes.

We also illustrate a tram rail track drill with automatic feed, which is supplied by Messrs. Selig, Sonnenthal. It appears in position ready for work. It can be conveniently thrown back or collapsed in a few seconds to allow cars to pass. The automatic feed enables the operator to drill through the web of the heaviest rail section without stopping. In these drills, strength and durability are especially claimed, and the chance of breakage of wearing parts is reduced to a minimum.



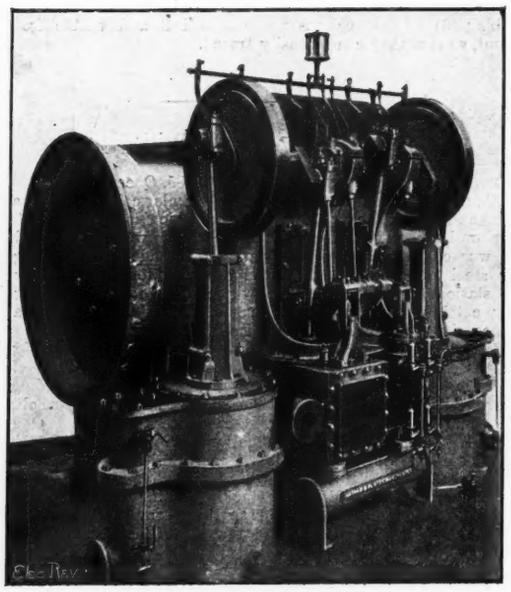
"Sundale" Circular Cold Sawing Machine.

The utility of this gear is at once apparent. It is a pleasure to know that in switchboard design we are able in this country to produce a more substantial and reliable apparatus than those manufactured abroad. We understand that Messrs. Ferranti

The same firm supply pressed-steel locomotive and wagon replacers, and many other articles (which are shown in their lists) for electric tramway and locomotive shops, including their hydraulic pit jacks and lifting apparatus.

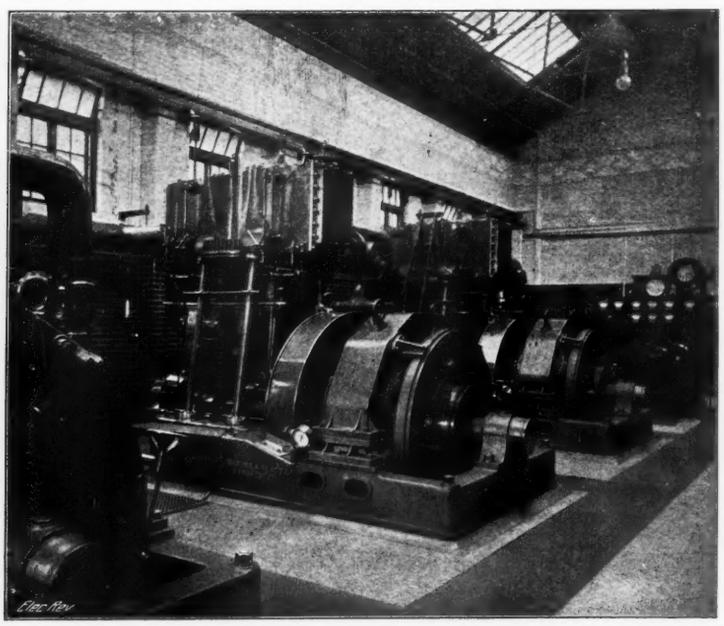
Power Station Plant.

Included in the wide range of work turned out by Messrs. Mather and Platt, Limited, of Salford Iron Works, will be found almost everything required for the equipment of tramway power stations,



1,800 I.H.P. Surface Condensing Plant.

with the exception of boilers and piping. We illustrate a self-contained surface condensing plant for 1,800 I.H.P., complete with steam-driven air-pumps. We also give a view of the interior of the Prestwich Corporation combined electric lighting and traction



Prestwich Electricity Works.

station, equipped with Mather-Platt steam dynamos; the engines are of the vertical compound open type, and the dynamos are of the multipolar traction type.

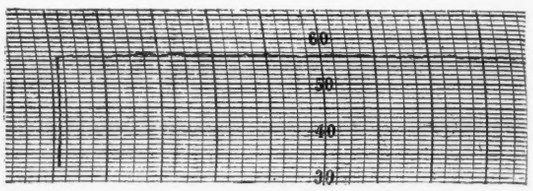
Amongst other traction plants equipped by Messrs. Mather & Platt, we may mention the City and South London Railway, Isle of Man Tramways, &c.

Recorders for Use on Tramcars.

The importance of being able to record the actual current taken by a tramcar at any moment at various parts of the route is so great, that various attempts have been made to utilise the ordinary recording instruments for this purpose.

There are, however, several difficulties to be overcome:—First (and this is a point of importance with all recorders intended for traction work), unless the instrument is absolutely dead-beat the record will be quite meaningless; secondly, the recorder must be mechanically strong enough to withstand very severe jolting without getting out of order owing to screws getting loose and so forth; lastly, the jolting of the car must not affect the reading of the instrument—that is to say, when a steady current is passing, a straight line must be drawn upon the chart, no matter how the car may be swaying about.

To meet the great demand which has arisen for a recording ammeter fulfilling these requirements, Messrs. Everett, Edgcumbe and Co. have introduced an ingenious modification of their well-known recorders.



Actual Record taken on Tramcar.

These instruments can be fitted with charts, either in the form of single sheets or of continuous rolls running at any required speed ($\frac{5}{8}$ in. per hour and 7½ in per hour being their standard rates), and are of the moving coil type. In the case of ammeters separate shunts are provided. For the particular purpose under consideration this is important, as it enables a shunt to be inserted at any convenient point in the circuit, while the recorder proper can be placed in such a position as to be readily accessible.

The outer case, which is provided with a handle for carrying, is only slightly larger than the firm's standard portable case. The recording mechanism, which, needless to say, is strongly and accurately made, is slung inside this case by means of springy couplings, in such a way that the vibration of the car is almost entirely damped out.

That the arrangement is perfectly successful is shown by the figure, which is from an actual record taken while a practically constant current was passin through the instrument. It will be seen that, in spite of the vibration the line traced by the pen does not anywhere deviate more than ½ per cent. from a straight line.

When it is added that the instrument is absolutely dead beat, it may safely be said that Messrs. Everett, Edgcumbe & Co. have found an extremely practical solution of the difficulty which has long beset those wishing to make accurate measurements on cars under working conditions.

Power Station Chimneys.

We describe below a form of chimney construction which has been adopted by a number of important electrical concerns in this country and abroad. It is known as the "Custodis" system; the chimney is round, and is constructed of specially moulded bricks. These special-shaped and vertically perforated blocks are manufactured from specially selected clay, which is considered much better than that of which ordinary bricks are made, as the latter mostly contain a large percentage of lime and other inferior foundations. The chimneys are of considerably less weight on account of the smaller wall thickness, but it is claimed that greater stability is obtained. This effects saving in cost and obviates heavy foundations, an advantage where the soil is bad or only limited space is available. In connection with the electric power station of the Hornsey Urban District Council, owing to the limited space available, it would only have been possible to build a chimney of 180 ft. by other construction, whilst the height of 200 ft. was the desideratum, and was made possible, by the "Custodis" construction. One special feature of the "Custodis" is that the firebrick lining is not a separate chimney itself, but is supported in sections by the outer shell. The Alphons Custodis Chimney Construction Company built four chimney stacks (250 ft. by 17 ft.) for the Manhattan Elevated Railway Company, of New York, within a period of six months. The same form of construction has also been adopted for the new works of the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park. We understand that the Metropolitan District Railway Company is about to place a contract with the company for four chimney stacks, each 275 ft. high by 19 ft. diameter, for their power station in connection with the operation of the Underground by electricity. A "Custodis" chimney has just been completed for the Eastbourne Corporation. The Alphons Custodis Chimney Construction Company, of St. Marie's Chambers, 6A, Norfolk Row, Birmingham, is looking after things in this country.

Electric Locomotives.

In fig. 1 we illustrate one of the motors made by the International Electrical Engineering Company, of Liège, for electric locomotives for working on main lines of railways, or for elevated or tube railways for intercommunication in cities or towns.

The company have supplied to the Belgian State Railways electrical equipments consisting of 100-h.p. gearless motors with suitable controlling gear, &c.

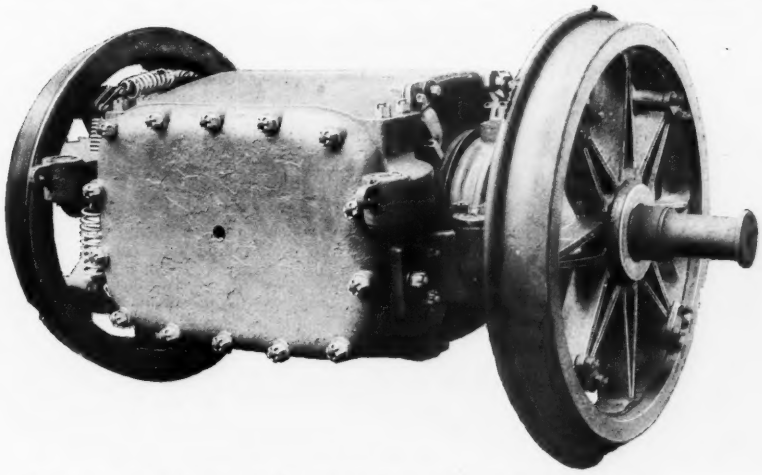
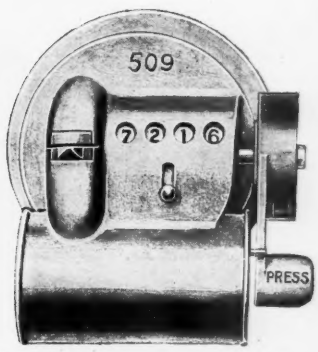


Fig. 1.—100-h.p. Gearless Motors on Belgian State Railways.



"Reliance" Conductors' Check.

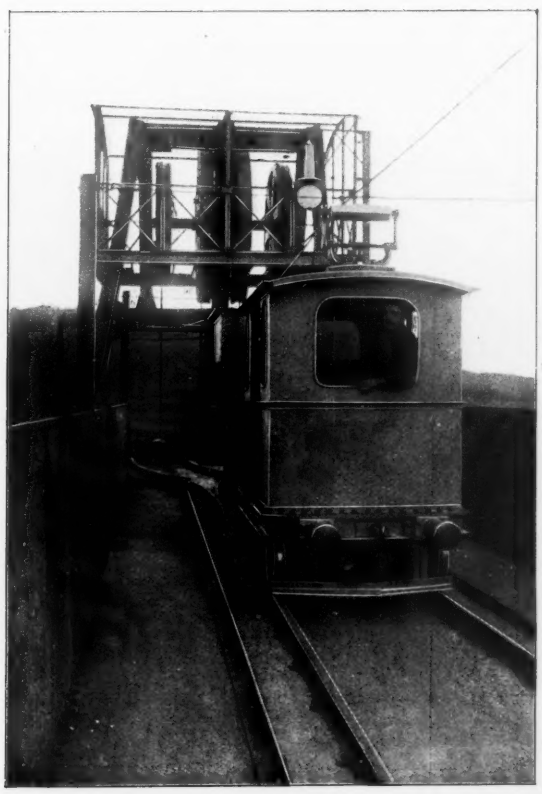


Fig. 2.—C.I.E. Locomotive.

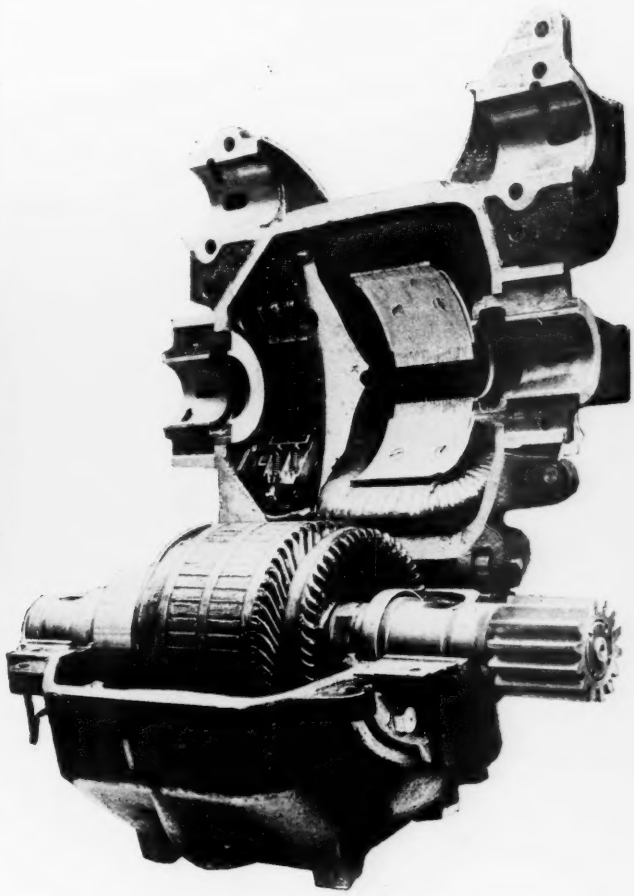
In fig. 2 we show one of the company's surface narrow-gauge locomotives in use on the Audun-le-Tiche blast furnaces.

Tram Tickets and Conductors' Checks.

Messrs. T. J. Whiting & Sons, Limited, of 7A, South Place, Finsbury, E.C., have for many years been specialists in the tramway ticket business, also in the details of car conductors' equipments, such as pouches, nippers, &c. Tramway managers throughout the kingdom, if not familiar with the firm's products, should write for a copy of their catalogue of specimen tickets, wherein are copies of the styles of tickets supplied by them for numerous towns in the United Kingdom, also in France, Germany, Argentina, Brazil, Buenos Ayres, Madras, Calcutta, Durban, and so on. We illustrate from among their other special lines, the patent "Reliance" check, which has a continuous register and so does not require re-setting. It can be used either open or closed. It is worn on the breast.

Tramway Motors and Equipments.

The International Electrical Engineering Company's tramway motors, such as those recently supplied to the Union Company, of Berlin, and 22 similar motors now on order for Liége, are entirely enclosed in a cast steel case, which effectually protects the armature, commutator and magnets from damp or dust. The upper part of this case has an inspection door giving access to the commutator and brushes, and the case itself opens in two halves, as shown in our

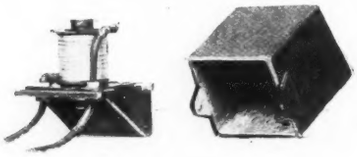


Tramway Motor, Open.

illustration, so that every part of the motor is accessible and the armature can, if necessary, be removed for repairs without detaching the whole machine from the truck. The brushes are of carbon and the commutation is sparkless.

The motors are as much reduced in size as possible, so that they can be readily mounted on the cars, to which they are attached by a spring suspension. They are geared to the axles by single reduction gearing entirely enclosed in wrought-iron grease-boxes. The running is consequently noiseless, and the wear and tear is reduced to a minimum.

The electric equipment of each car consists of two series wound motors. The controller is so arranged that the two motors can be put in series with each other at starting, obtaining thereby a very powerful starting effort. The controllers, two of which are placed



Lightning Arrester.

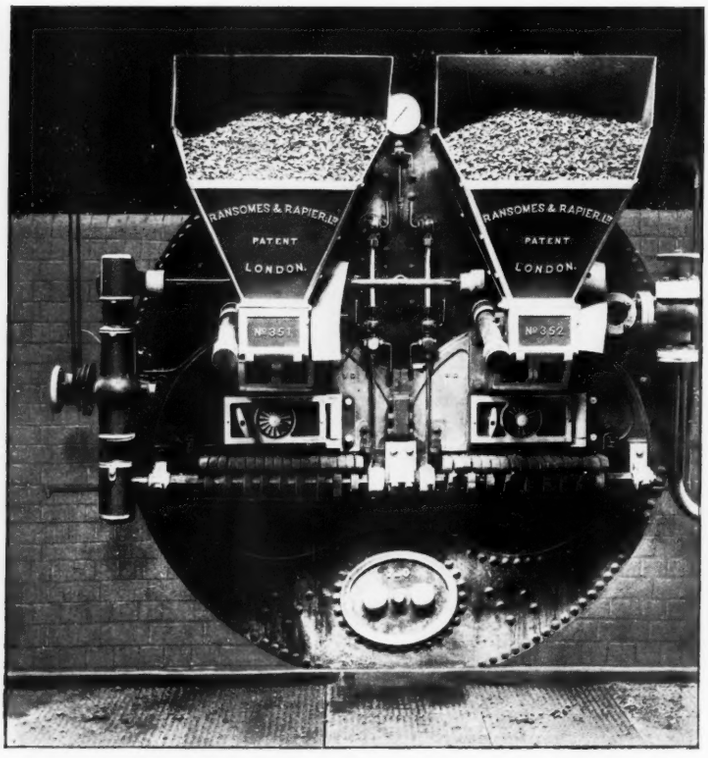
on the platforms of each car, have been designed by the company with a view to rendering their manipulation as simple and mechanical a matter as possible. They are, like the motors, entirely enclosed and protected from wet or dust.

An inspection door is provided which gives access to the interior mechanism of the controller, and there is a special arrangement which, in the event of injury to one of the motors, enables it to be disconnected from the circuit, the car then being driven by one motor only.

Besides the motors and controllers, the cars carry speed regulating resistances, and various safety apparatus such as lightning arresters, fuses, and automatic cut-out, the last-named coming into operation when there is an excess of current likely to cause damage to the motor.

The "Triumph" Stoker.

For traction power stations this machine, which we illustrate below, is considered by many eminent engineers to be one of the best mechanical stokers, and it is rapidly taking its place in the front rank of these indispensable and economical adjuncts to all modern electric plant. At the Sunderland Corporation Electricity Works, which supply—in addition to the lighting—the power for the extensive system of local tramways, the "Triumph" stoker was thoroughly tested, in competition with another sprinkler stoker, and a well known coking stoker, over a period of some months under actual working conditions, and subsequently an exhaustive 12 hours' test was conducted by the borough electrical engineer. As a result, eight of the boilers at the old station, and the whole of the boilers at the new station, are now fitted with these machines. Incidentally it may be remarked that the total costs at these works according to the last published return have been brought down to 1·78d. per unit—one of the lowest costs in the United Kingdom. Furthermore, we are informed that the absence of smoke is a very noticeable feature of the Sunderland works. The stoker is supplied by Triumph Stoker, Limited, of 39, Victoria Street, S.W.



'Triumph" Stoker at the Seaton Carew Ironworks, West Hartlepool.

Rankine Feed-Water Filters.

These well-known filters, which possess a great reputation in marine engineering, have also firmly established themselves on land, being in use in numerous engineering works of all descriptions. The compound filter which we illustrate (fig. 1) is specially adapted for dealing with very thin qualities of cylinder oil; experience has shown that for this purpose double filtration is essential. The filtering arrangement consists of an outer cylindrical cartridge, having flanges at each end to take the walls of the filtering chamber; this is covered with two or three turns of filtering material, as may be required, and forms the first filtration of the feed water. Into this cartridge is telescoped a frame with a series of seven smaller cartridges; these cartridges are also covered with filtering material, the latter being of double thickness and drawn over each cartridge like a stocking. This forms the second filtration. The entire filtering arrangement fits close up to a collar at the outlet end of the filter and is held in position by the cover or door. The splitting up and redistribution of the feed water, over a second filtering surface greater than the first, not only more effectually extracts the oil from the feed water, but creates a natural flow in the filtration, thus avoiding the resistance that would be set up if the cartridges were concentric with one another. A number of these filters are already fitted to electric light plants, factories, &c., where oil is used in large quantities, and they have proved most effectual; amongst other installations we may mention electricity works at Shoreditch, Wallsend, Leicester, Hamburg, Newcastle-on-Tyne, and the tramway power stations at Portsmouth and Durban.

A simple type of filter is the "single cartridge" pattern shown in fig. 2. This filter consists of an egg-ended cylindrical cast-iron or gun-metal filtering chamber, formed on lines which give the greatest possible strength together with compactness and efficiency. The valve chest and inlet and outlet branches are cast on the chamber, which not only makes the apparatus more compact, but economises space. The internal filtering arrangement is cylindrical and concentric with the filtering chamber. There is a diaphragm at the outlet end, on which a spigot is turned to take the filtering cartridge, which is guided to its position by means of a guide-bar at the bottom of the filtering chamber. The diaphragm is bored

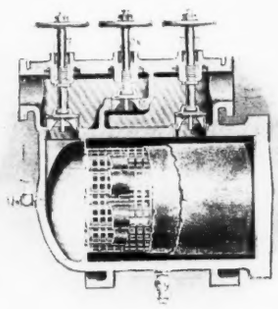


Fig. 1.—Rankine Compound Filter.

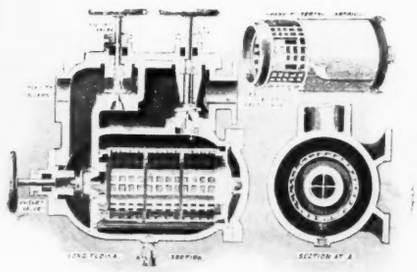


Fig. 2.—Rankine Single-Cartridge Filter.

out to form a seat for the outlet valve of the filter, and directly behind the diaphragm is the outlet passage of the feed water. Three valves, an inlet, outlet, and bye-pass are provided. A light spigotted end-cover is fitted.

The internal arrangement consists of a cylindrical cartridge of phosphor bronze, made in the form of a grating, and is closed at one end by means of a turned cover, which is secured to it by screw bolts; the end is also turned up to fit the diaphragm seat at the base of the cartridge, and the closed end is turned up to fit the mouth of the filtering chamber. This forms the cartridge proper. Two or more turns of filtering cloth are then wound round the filtering cartridge, and secured at the ends with straps and buckles. A rubber buffer is fitted into the recess of the door of the filter, which compresses the closed end of the filtering cartridge, thus holding it in place.

This filter occupies little space, is easily fitted, requires little attention, and can be overhauled in a few minutes. It has been supplied to Sydney (N.S.W.), South London, and other electricity works.

The Rankine Patent Feedwater Filter Company, Limited, whose office is at 14, Water Street, Liverpool, also make multiple cartridge filters, for single, double and triple filtration, and have supplied great numbers to the mercantile marine, and to foreign governments. Their business is *entirely* devoted to the study of feed water filtration, so that they have acquired a unique experience in this subject.

Tramway Track Construction.

The name of Messrs. Askham Bros. & Wilson, Ltd., of Sheffield, is well known to tramway engineers. Some of their latest improvements are illustrated herewith. Fig. 1 shows their patent joint plate for new track construction, for which an enormous demand has been

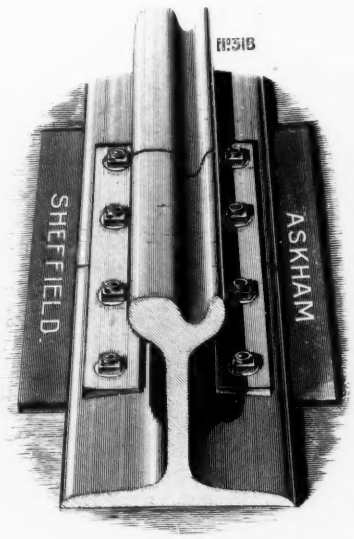


Fig. 1.

experienced. The rails are punched at the works to suit the plates. The advantages of the joint are self-evident; the plates are fixed exactly where the tensile stress is greatest, regarding the joint as part of a girder, and the large under-plate distributes the pressure at the joint over a large surface of road-bed. A similar type of joint plate is made for repairing and strengthening existing tramways for conversion to electric traction. Fig. 2 is an illustration of Dawson's patent drain rail, in crucible cast-steel. The figure shows Messrs. Askham Bros.' improved pattern, with projecting chair ends for carrying and bolting down the connecting rails, preventing oscillation and ensuring a rigid joint, on the same principle as the joint-plate above mentioned. The drain box is also made separately for bolting to the ordinary rails. Fig. 3 is a patent movable point for junctions and cross-overs; this has a stud and spring underneath the tongue, which ensures the tongue springing to right or left without stopping in an incorrect position. Fixed automatic points are also made on similar lines. Fig. 4 shows a complete junction ready for laying. Messrs. Askham Bros. are now making a special feature of the construction of loops, lay-outs, junctions, &c., in their works before delivery, and are carrying out large contracts of this kind for Manchester, Yarmouth, &c. The above are merely a selection from the varied types of special work, points and crossings, &c., made by the company, but they will serve to indicate the scope and variety of the work which they undertake, and with which their shops are now fully occupied.

Trolley Wheels and Trolley Ears.

The Western Electric Company, Limited, of 171, Queen Victoria Street, E.C., are manufacturers of a specially light and strong type of car, which has been specified on the Buffalo Road, and was used entirely on the roads leading to and about the Pan-American Exposition this summer.

Their No. 3,712 wheel is made of the best metal, and the groove, one of the most important parts of the wheel, is the result of much careful investigation and trial. It is recommended as having a shape that will give the greatest amount of wear to the metal in the wheel. It will not permit the trolley to cut to one side, nor to slip from the wire on curves, and it easily takes frogs and ears.

The Western Electric sleet wheels are so designed that they will not catch in a frog, and it is impossible for them to tear the wire.

The W.E. clip is an automatic clip made of drop forged steel which has a height of 2½ in., and a length of 4½ in., weighs 8½ oz., and is claimed to possess the following valuable features:—It is automatic in its adjustment to any size of wire from No. 2 to 00. Its height is but 2½ in., bringing the trolley wire nearer to the span wire than any other clip or soldered ear. It is adapted to fit any hanger having a ⅝-in. stud, without the aid of any extra attaching plugs or special attachments of any kind. It is quickly adjusted, requiring but 30 seconds to adjust to the wire without the aid of any special wrenches or tools, and without kinking, bending, or marring the wire in any way. Being made of drop forged steel throughout, the grip which is obtained on the trolley wire is limited only by the amount of power which is applied to the expansion nut, making it a very powerful clip and applicable for use on curves as well as straight lines, as it will not slip on the wire. The trolley wheel does not touch the clip. The clip is V-shaped, like the groove in the wheel, tapering to a point where it clamps the wire, which it does with

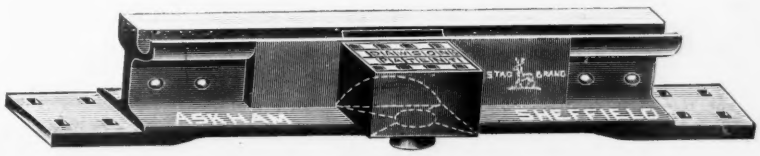


Fig. 2.

Fig. 3.

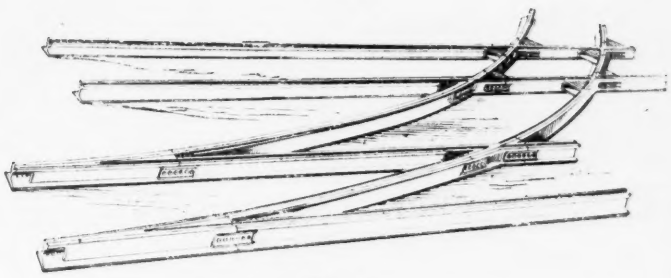


Fig. 4.

knife-edges of steel in such a manner as to leave the bottom of the wire perfectly bare and free, giving a smooth, unbroken line for the wheel to travel on. There is no wear on the clip, and the wear on the wheel is greatly reduced by avoiding the usual jump and consequent spark to the wheel when passing clips of other design.

The company also supplies a changeable headlight. Only one headlight is required for each car. The motorman, when wishing to change the headlight, merely has to pull out the reflector from the socket, carry it to the front of the car and attach it in the same way as a plug.

The Stombaugh guy-anchor is a simple and cheap form of guy for bracing a pole of any kind. It is screwed into the ground like a corkscrew into a cork, in no way disturbing the ground surface, so that the soil is packed around the anchor itself by nature. These anchors are furnished in sizes from 3½ in. to 12 in., and the larger sizes, *i.e.*, from 6 in. up, will carry almost any strain.

The company's new round top insulator has the double petticoat, and has the under-brace on the arms. The makers claim as a special feature the mechanical strength of their span clamp. Its weight is slightly more than 1½ lbs., and it has nothing whatever breakable in it, and no loose parts.

The insulated trolley crossings are of such a construction that the insulation between the wires is very reliable, and the course of the trolley wheel passing under is perfectly straight and uninterrupted.

There is sufficient strength to stand the strain of the wire without buckling. This crossing will take an angle of 90 to 75°. The insulated runners are renewable, and are provided with auxiliary metal terminals, so that the sparking is all taken by the renewable parts. A fibre hood covers the centre.

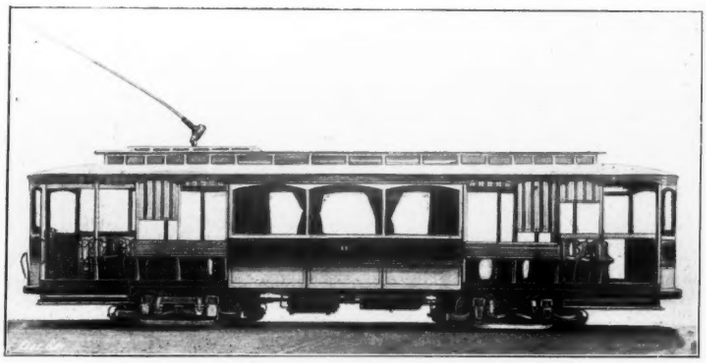
The Camp's Bay (Cape Town) Tramways.

An interesting tramway system is now being laid down at Camp's Bay, Cape Town, for which Messrs. Dick, Kerr & Co., of 110, Cannon Street, E.C., are supplying the power plant and the rolling stock. The system comprises eight miles of route, and presents certain difficulties on account of the somewhat severe gradients on the line.

The type of generators supplied in this case is that with which Messrs. Dick, Kerr & Co.'s name has been prominently associated of late, and is made by the English Electric Manufacturing Company; an illustration of this generator appeared in these columns some weeks ago.

The power house plant comprises two engines of 550 h.p. each; they are of the horizontal compound type, and are direct connected to two continuous current generators. The latter are of the compound type, designed to give at full load 700 amperes and 500 volts, and are further specified to give as a maximum load 900 amperes each.

The rolling stock differs materially from the type of car used in this country, such variations being necessary on account of the different climatic conditions prevailing. There are some 20 cars, 15 of which are of the gridiron or open pattern; there are also five which are known as the combined type, and one of these we illustrate. The former has a seating capacity for 65 passengers and the latter for 55. It will be noted that the cars are of the single-deck pattern, a feature of interest in both being the vestibule construction, which is closed in at the end, thus giving protection to the motorman. The cars are mounted on bogie trucks, the chief feature from an electrical point of view being the use of four motors. There are distinct advantages in the use of four-motor equipments in places where severe gradients exist, and though the apparatus is more expensive than with two motor cars, the expense is certainly justified under many conditions.



Camp's Bay Combination Car.

The motors on the Camp's Bay cars are of 15 h.p., 500 volts each, the method of gearing being in all respects similar to ordinary practice.

The controllers are specially designed for four-motor equipment, although they are part of the standard practice of the English Electric Manufacturing Company, Limited. They are of the solenoid type, designed to give easy acceleration to the car, and an equal division of work between the motors, during the various combinations.

There are the usual reversing switch and resistance coils, and the necessary automatic cut-out boxes.

Each car is fitted with three brakes; a hand brake, an air brake and an auxiliary slipper brake, which can be applied at four points of the rail.

Hadfield's Manganese Steel Track Work.

A large amount of work has been and is being done by Messrs Hadfield's Steel Foundry Company, Limited, of Sheffield, in connection with electric tramways; their special product—manganese steel castings—being exceedingly hard, and at the same time very tough, is admirably adapted for special work, points and crossings, &c., the wear and tear on which is otherwise a constant source of trouble and expense. Our illustrations show some of Messrs. Hadfield's special designs. Fig. 1 is a view of an ordinary frog crossing. Fig. 2 shows Hadfield & Hatton's combined crossing and sole plate, which is being widely used for the Salford track work, under the superintendence of Mr. Ernest Hatton, general manager of the tramways. This is made of manganese steel, and in addition to great durability, it gives greater rigidity to the permanent way, the rails being bolted on the sole plate. Further, the surface exposed to the traffic is a minimum, which is good for both the traffic and the crossing.

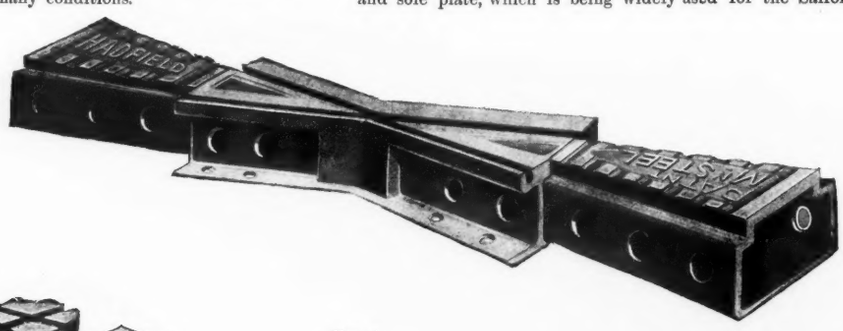


Fig. 1.

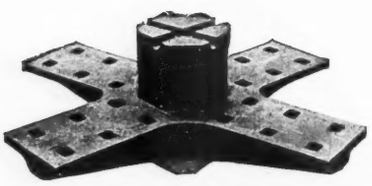


Fig. 2.

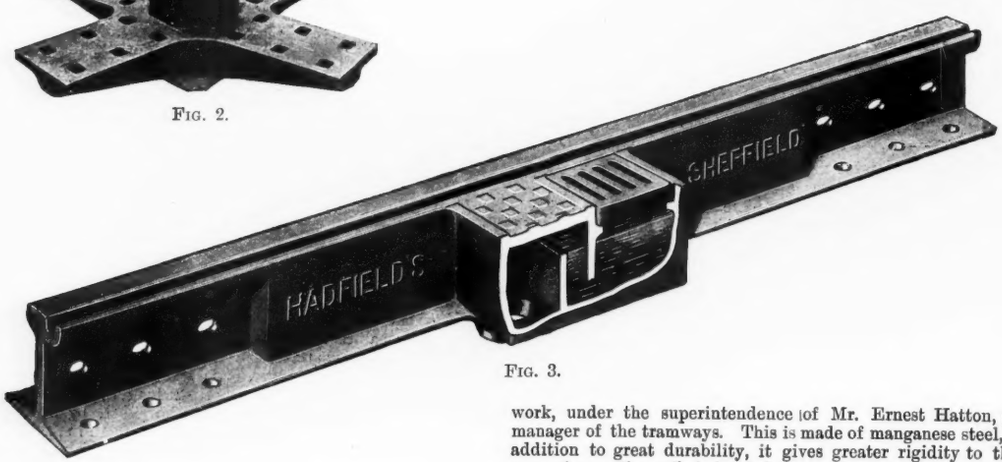


Fig. 3.

Fig. 3 is a view of Hadfield's patent drain rail. This is made, as shown, with a short length of rail cast in one piece with the drain box, or the box can be obtained separately for bolting to an ordinary tram rail. It will be seen that the box is an effective gas trap, and is readily opened for cleaning and inspection.

Fig. 4 shows a section of Hadfield's improved patent point, which can be converted in a few minutes from a movable to an automatic spring point, or *vice versâ*. Fig. 4 shows the movable point, with a spring attachment to prevent the tongue from remaining in a neutral position. The same box is used for an automatic pulling or pushing point, the only difference being in the arrangement of the spring. The tongue is not kept in position solely by the bolts which pass through it; the point is so designed that it is the exact shape of the ball end of the tongue and is machined to fit it. It is

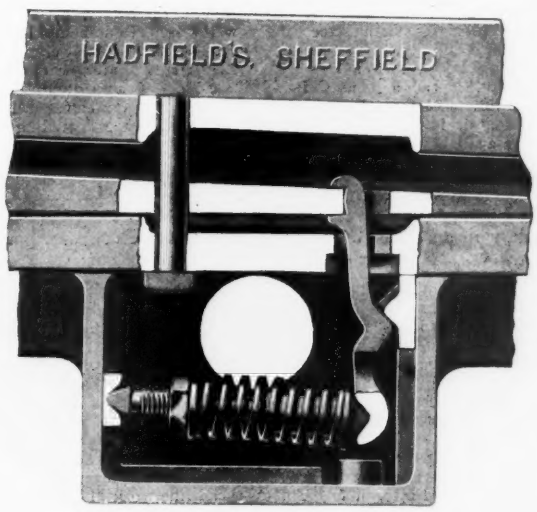


Fig. 4.

impossible for the tongue to rise whilst in use, or otherwise to move out of its correct position.

Fig. 5 is a view of the lay-out at Fitzalan Square, Sheffield. Messrs. Hadfield's works are equipped with special tools and appliances for bending rails and building up complete lay-outs, ready to be fixed in position, and they have supplied lay-outs to Bolton, Stockport, Birkenhead, Doncaster and other Corporations.

The Sheffield lay-out, which is the most important junction in the city, is made of manganese steel throughout, including the rails. It has taken the place of the ordinary cast-steel points and crossings previously in use, which were a constant source of trouble; the working conditions are such as to subject it to exceptionally severe service. The curve comes on a very steep gradient, sloping rapidly from High Street to the Haymarket, and on account of the roadway into Fitzalan Square and Commercial Street, no super-elevation can be given on the outer track of the curve; in fact, the crossfall is in the wrong direction.

The rails were formed of a bridge section, and were cast in lengths

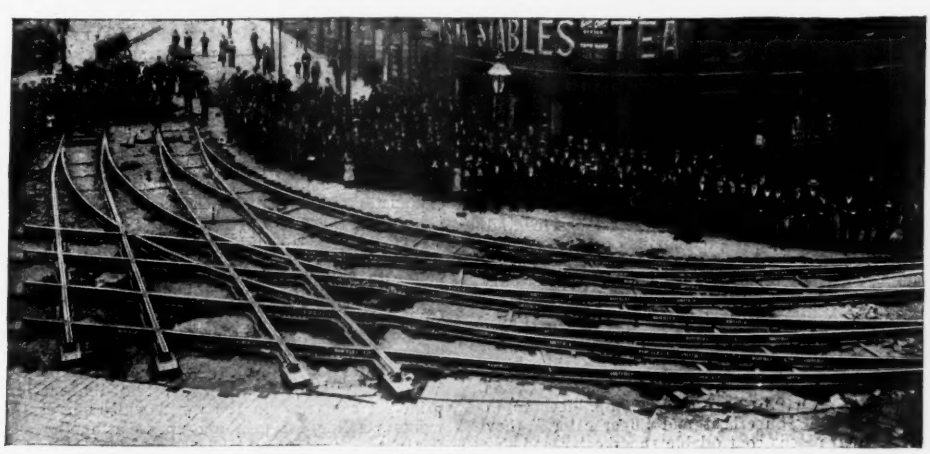


Fig. 5.

of about 13 ft., with cross-ribs at intervals of about 18 in., so as to give greater strength and rigidity. The joints were made under the patent of Mr. Hadfield; a strong cast-steel soleplate is inserted at each joint, and this is secured to the lower flange of each rail by six bolts, four of which are turned and driven into bored holes, thus effectually preventing the rails from separating from each other. Where holes were required, wrought-iron bushes were cast in, which, of course, could be bored, and thus ensure the essential accuracy of fit. At the end of each rail, and near the top, half bushes of wrought-iron were cast in, and when the rails were fixed in position, these two half bushes were bored, thus forming a round hole into which a bolt was driven. The object of this bolt is to prevent any vertical motion of one rail in relation to the other, so that the surfaces of the rails are kept perfectly in one plane, and when the nut is screwed on the bolt, it also prevents the rails from moving sideways. This combined method of fitting ensures an absolutely rigid job; considered as a girder, the joint is an exceptionally strong one.

The crossings are not of the ordinary design; in many cases what would ordinarily be three crossings, are combined in one casting. The points are of the improved design already described.

The whole lay-out was constructed with great accuracy and smoothness. Messrs. Hadfield's obtained this degree of accuracy by grinding the track where necessary, either in the grooves, or on the surface, so as to ensure the correct gauge, a level surface, and finally, smoothness for running.

The company have supplied numerous corporations with points and crossings, of which they can turn out 120—140 points and 80—90 crossings per week; they are also making the points and crossings for the South Lancashire Tramways Company's 80 miles of track, as well as for the North Shields and the Tyneside tramways. The company also make steel car wheels, with tires of a special quality of steel, for which greater durability and reliability are claimed than for chilled iron wheels.

Traction Trade Catalogues and Announcements.

The Fleming Dynamo Brush Company, of 41, Corporation Street, Manchester, have placed before us a list describing their patent wire gauze dynamo brush, which they have made in 200 different sizes. The brush is composed of gauze cloth of high conductivity pure lake copper, the copper wire being drawn to 34 B. and S. and then woven to a mesh of 3,600 to the square inch. The makers claim that, by the process of manufacture, an article is produced which, when placed on a commutator in good condition and properly adjusted, is absolutely sparkless and noiseless, and requires no further attention. It is also compact and flexible, readily adjusting itself to the surface of the commutator, ensuring good contact, though bearing lightly and evenly on the segments, thus reducing to a minimum the wear on this part of the dynamo.

The Victor Cooling Tower Company, of St. Louis, U.S.A., in their catalogue, No. II., give a full illustrated description of their Victor atmospheric water-cooling towers for condensing engines. The Victor self-cooling condenser (with fan tower and jet condenser) as used in electric light and street railway work is shown.

The General Electric Company (1900), Limited's list of traction supplies should be of practical service to tramway managers and borough engineers who are in the market, from time to time, for overhead line material and other traction details.

Messrs. Holden & Brooke, Limited, of Sirius Works, West Gorton, Manchester, have in circulation a number of lists of their "Sirius" injectors of various patterns, pumps, oil separators, valves, feed water heaters, steam traps, and sundry steam auxiliaries and fittings of a like character.

Messrs. R. & J. Dick, of Greenhead Works, Glasgow, have placed before us lists of their Jackson's patent plate, oval and other fasteners for driving belts and straps of electrical and other machinery. One of the lists contains a report noting the satisfactory results obtained with the use of Dick's patent belting in a warm climate and in a variable temperature. These belts are made in gutta-percha, canvas, and balata, and their sale is rapidly increasing in this country, as well as in the Colonies and foreign parts. The firm's excellent exhibit at the late Glasgow International Exhibition will be remembered by many of our readers.

Messrs. Mosses & Mitchell's insulating saddle staples are familiar to the trade, being largely employed by many electrical engineers in different parts of the country. Their hard vulcanised fibre also appeals to electrical and tramway men, being so excellent a non-conductor.

Every tramway power station must, of course, have its mechanical equipment if it is to deal with its large fuel supplies and stores in a

way that shall ensure the greatest economy being obtained under this head. The elevating and conveying machinery of Messrs. Graham, Morton & Co., Limited, of Leeds, is already pretty familiar to readers of the ELECTRICAL REVIEW on account of our descriptions of their plants introduced into various electric power stations. Tramway men who are equipping power stations are not likely to pass the firm's name by when fuel-handling arrangements are occupying their attention. Their fully illustrated catalogue deals with all kinds of coal and ash-handling apparatus.

The Shelby Steel Tube Company, of 29, Constitution Hill, Birmingham, are making a speciality of trolley poles, which they are anxious to bring before tramway officials.

The Lahmeyer Electrical Company, Limited, of 109—111, New Oxford Street, W., have lately issued new price lists and catalogues, all got up in fine style and fully illustrated, in which their many special lines of manufacture are dealt with. These, of course, include alternators, balancers, boosters, controllers, dynamos, motors, regulators, resistances, switchboards and transformers. A special brochure contains an illustrated description of the works at Frankfort, from which an idea can be obtained of the work carried out there. The works are well equipped with the most modern machinery, and manufacturing methods are highly organised.

Messrs. Thomas Bolton & Sons, of Widnes, and other places in the country where their mills and factories are situated, supply trolley wire in long lengths, of every description, and also all sizes of commutator bars, drop forgings, &c. Any engineer who cares to take the trouble to write for it to 90, Cannon Street, E.C., can have one of their useful books of stock sections of commutator bars.

The "Economic" Manufacturing Company, of Springfield, Ohio, who are represented in this country by Messrs. Blackwell, have sent us lists of their "Economic" swivel trolley harp, which they claim will take an overhead frog with certainty, and which is largely used in the States.

The Western Electric Company, of North Woolwich, have placed before us one of their catalogues of power motors. Dynamos and motors, enclosed, semi-enclosed and open, of different styles are detailed; slow speed multipolar machines, continuous current transformers or motor-generators, dynamotors, twin motor-generators, direct connected engines and dynamos, are also described and excellently shown by means of half-tone and line blocks. Several pictures show some of the applications of the motors to driving machinery. A number of loose sheets give tabulated data, with prices of motors of $\frac{1}{16}$ to 15 H.P.

In a recent issue we described the traction telephone apparatus of the General Electric Company (1900), Limited. We understand that the company has now introduced several additional novelties and improvements in connection with the system.

Messrs. Veritys, Limited, are at present very busily engaged preparing a traction catalogue on a large scale. It will be issued shortly.

The British Schuckert Electric Company, of Clun House, W.C., have issued a new list, No. P 14, of their measuring instruments, continuous current and alternating ammeters and voltmeters.

From Messrs. Geipel & Lange, of Parliament Mansions, Westminster, we have received various lists of their special lines. These include a net trade price list of the well-known Ward-Leonard rheostats and circuit-breakers, for which they are the sole agents here; "Okonite" for insulated joints, the Vulcan two-wire watt-hour-meters (prepayment type) are also the subjects of lists sent.

The Chicago Truck Company, of 1,062 and 1,063 Monadnock Block, Chicago, Ill., have placed before us a catalogue in which are fully detailed and illustrated the Curtis patent trucks for electric service. The prefatory remarks say that in changing from horse traction to electric, truck builders attempted to construct a motor truck, using as part of the construction, the ordinary gears used under horse cars, with the result that failure ensued, and truck-builders set out on wrong lines, which did not ensure the best car-riding effect nor keep down the repairs expenditure. Starting late in the day, the Chicago Company claim to have benefitted by the disastrous experience of others, and to employ improved designs and constructions, so that they claim as special points in their trucks, superior riding qualities, excellence of construction, and general utility and strength. We note brief descriptive details and capital illustrations of trucks of different types for various kinds of service, some for high speed heavy work, some for elevated railway lines, some for city and suburban service, and trucks equipped with Curtis patent inside-hung brake without beams.

The Cruse Controllable Superheater Company, of 5, Blackfriars Street, Salford, Manchester, have brought out a 50 pp. brochure, in which, under the title of "Superheat and Superheaters," they describe and discuss their patent controllable superheater and dry steam generator, which is adapted to all classes of land and marine boilers. The Cruse superheater is fitted in the fullest heat of the furnace gases, so that the highest efficiency may be obtained. It is built up of wide bore weldless steel tubes, and the steam flows in counter-current to the gases. It contains within itself its own superheat controlling and tube-preserving element, viz., columns or cores of water in circulation in copper tubes inside the steel superheater tubes. By this method the superheat is automatically regulated to a given maximum temperature, and is capable of easy adjustment to within a few degrees, to suit the requirements of the moment. The regulating element, which is the water circulating to and from the water space of the boiler, absorbs in its passage through the internal tubes the excess of the heat imparted to the steam by the furnace gases, and returns it to the boiler to assist in the generation of further steam therein. The essential feature of this patent superheater is this power of controlling and regulating or varying the temperature of the superheat, by the circulation of water of different volumes and degrees of temperature through the inner tubes of the apparatus, the adjustment being effected by the manipulation of the valves on the water supply pipes. This method of control operates to transform the entire apparatus into an efficient and economical combination of four distinct elements in boiler practice, viz., a steam generator; a superheater simultaneously controlling and regulating the superheat; a boiler water circulator; a feed water heater.

Messrs. Robey & Co., of 79, Queen Victoria Street, E.C., and Lincoln, have issued an exceedingly well set-out little pamphlet in which we find illustrations and description of their Glasgow exhibits, showing the types of engines which they manufacture for electric lighting, traction and transmission, for either private or temporary installations or central stations. They are made either vertical or horizontal, low or high speed, open or closed type, according to space available and local conditions. The illustrations show engines arranged for belt drive or direct coupled. They manufacture all descriptions of simple, compound, tandem and coupled engines designed to suit any make of dynamo. The latest improvements have been introduced in the way of "trip" and other forms of valve gear, with a view of obtaining the highest degree of economy and efficiency.

Messrs. R. W. Blackwell & Co. have issued a complete set of their catalogues, covering everything required for electric tramway equipment or maintenance. The catalogues cover pretty well the whole scope of electric traction. The firm have secured orders from two French tramways for hydraulic wheel presses. These two machines will be made in England. They have also booked a contract for the construction of an electric tramway at Weston-super-Mare. The contract includes the track, the overhead construction, and bonding. Further, they are supplying the British Thomson-Houston Company with 52 Peckham trucks for the Leeds Corporation tramways; and have just secured a contract for two further extensions at Nottingham. The overhead line work at Nottingham is of the latest and most up-to-date type; the electrical details were designed by Mr. Talbot, the city electrical engineer, and the mechanical details by Mr. Brown, the city surveyor. Messrs. Blackwell's electrical supply catalogue deals with a variety of car-shed fittings for lighting purposes, switches innumerable, and such-like goods. A catalogue will also be issued in a few days thoroughly dealing with controlling rheostats for motors, dynamos, &c., electrical instruments, electrically-operated switches, and the Packard incandescent lamp.

The Bullock Electric Manufacturing Company, of Cincinnati, O., U.S.A., have placed before us details and illustrations of generators and other machinery for tramway power stations, as supplied by them for many American undertakings. These describe two of their 800 KW. railway generators on test; the power plant of the Peoples' Railway, Wilmington, Del., containing three 250-KW. and two 350-KW. Bullock belt-driven generators; the power plant of the Oakland Transit Company, Oakland, Cal., 800-KW. railway generator; the 250-KW. generator installed at San Juan, Porto Rico; a 1,000-KW. armature; a partly wound armature for 200-KW. belt-driven railway generator; the ratchet mechanism used on Bullock machines above 200 KW. for constantly shifting brush holder yoke laterally. (This produces the same action as the movement of the armature in belted machines, and prevents the cutting of the commutator, as it constantly changes the brush travel.) Also a 250-KW. railway storage battery booster, and a 600-KW. three-phase Bullock generator for long-distance power transmission.

Messrs. J. Stone & Co. have issued an admirably-illustrated book, with art printing and excellent photographic reproductions showing trains on some of the great railway systems of the United Kingdom in which the "Stone" patent electric lighting system is employed. This system of train lighting, which is pretty familiar to our readers, is described and its advantages detailed, estimates of cost and explanatory diagrams being shown.

"The Rapid-Transit Problem in London" is the title of a pamphlet now before us, in which Mr. Frank J. Sprague places before the reader the advantages of the multiple unit system in its application to railway service. Illustrations are given of trains operating on this system in France, Boston and Chicago. The article is reprinted from the *Engineering Magazine*.

COMMUTATOR GRINDER. — Messrs. Phillips & Co., of 166, Walworth Road, S.E., have patented a machine in all the principal countries in the world which answers all the requirements possible for grinding up a commutator of any size perfectly true and round. Their machine is fixed, in cases where rockers are used, to the rocker bearing, which ensures a rigid base; it is right on the job and true with the axis, an advantage which can be at once seen. The only measurements required are the sizes of the largest rocker bearing and commutator, distance rings being supplied down to the smallest. Where no rockers are used, as on multipolar dynamos, the same machine is fixed to the pedestal bearing, no holes whatever being required. This machine can be fixed in less than a quarter of an hour, and a commutator can be ground up in about two hours. As to the construction of the machine, the frame itself is practically a half circle fitted with bottom half or strap to cramp up to the bearing. The top half has a vertical plate cast on it, which at right angles to the axis of the shaft carries a slide controlled by a screw by which the feed is adjusted. Upon this slide is fitted a strong saddle varying

in length according to the length of the commutator to be dressed. To this is fitted a slide carrying a long roller fixed to the spindle of the emery wheel, and when the emery wheel spindle is out at its fullest length it is rigidly supported by this strong slide. The machine is driven direct off the commutator by means of a specially prepared rubber friction wheel, pressed down by a spring which yields to the unevenness of the commutator in the first stage of truing up. An automatic feed, simple and ingenious in design, and constructed so as to be able to set stops—as in a planing machine—to suit any length of commutator, and automatically reversing itself at each end of a predetermined traverse, renders this little machine, travelling to and fro, grinding the surface right up to the connecting wires and back to the edge, absolutely automatic, requiring practically no power to drive it. Many of our largest electricity stations are taking up this invention, and several dynamo and motor manufacturers are now using them for grinding up commutators in their places before leaving their works, and others are adopting it in conjunction with the lathe for which Messrs. Phillips supply a special arrangement. These manufacturers grind them up after the armature has left the ovens, thus, besides finishing them off in a far more satisfactory manner, avoiding re-turning the commutator and wasting the copper of the plates.

The serious accidents which have occurred from time to time through drivers losing control of their cars show the necessity of having an emergency brake fitted to every car, capable of stopping the car on any gradient and at any speed. At the same time, the connection between the brake and the car should not be so rigid as to violently shake the car and passengers. The pneumatic brake designed by Messrs. Hewitt & Rhodes, consulting tramway engineers, of Manchester, is intended to meet the requirements of instantaneous operation and elastic connection with the car; it acts directly on the rails, and is worked by air pressure from a compressor driven by one of the axles of the car. The brake can be fitted to any kind of truck; four brakes are used on each car, whether bogie trucks or single trucks are employed, as the designers found that if two brakes only were used a large proportion of the weight of the car was thrown on the front wheels in descending an incline. The brakes are applied by means of a handle near the hand-brake, and a pressure gauge is provided to show what pressure is available. The brake has been fitted on the cars of the Oldham and Stockport Corporations, and is being tried on the British Electric Traction Company's cars at Hanley, as well as several other electric systems. The air compressors on the Oldham Corporation cars have required no attention or repairs during the last 12 months, while the cars have each run over 25,000 miles. Apart from the renewal of the wooden brake blocks, the brakes themselves required no repairs.

One of the objections often raised to circuit breakers is that they act too suddenly, as, for instance, where one or more dynamos are supplying current to a number of feeders, which are themselves protected by circuit breakers. Should a short occur on the line or on one of the feeders, the circuit breaker on the dynamo is liable to open as well as the one on the feeder, although it may be set to operate at a higher current, and so cut off the supply of current to other feeders. Messrs. Ernest F. Moy, Limited, of Greenland Place, Camden Town, London, N.W., supply a circuit breaker especially designed for traction work. It is fitted with Moy & Bastie's time governor, the object of which is to introduce a lagging action or time element into it when it is used on a dynamo, to prevent it acting as quickly as the one on the feeder, while at the same time it is left free to act should it be required. This result is obtained by fixing a rack to the top of the rising core, which gears into a pinion on a spindle carrying a small fly-wheel. On the current reaching a point at which the circuit breaker is set to act, the core rises in the usual manner, except that at the first part of its movement it is slightly retarded by the inertia of the fly-wheel, which it has to start revolving. This impedance gives time for the circuit breaker on the feeder or circuit where the overload has occurred to act first. With two circuit breakers, one with the time governor and one without, it has been found that if they are both connected in series and both set to break at the same current, the one without the time governor will always open first, either on a gradual rise in current or on a dead short circuit. In testing the two circuit breakers in question separately it is quite impossible to realise that there is any difference in the time they take to act; the action appears to be instantaneous in both cases, and the difference is really only a very small fraction of a second. These circuit breakers are made in various sizes up to a carrying capacity of 1,500 amperes to break on 550 volts. Messrs. Moy also make a return current cut-out designed to break only on an actual reversal of the current. It can be set to break on a reversal of about 5 per cent. of its full carrying capacity. Obviously this possesses great advantages over the ordinary minimum cut-out when used for protecting dynamos running in parallel. It is made in a range of sizes up to 2,500 amperes. A new and very compact form of field regulating resistance, suitable for the large dynamos which are now so common in traction stations, is designed to go below the floor level and to be operated by a handwheel on a column in the switch gallery. The resistance coils are all enclosed in a perforated steel case. Messrs. Moy also make a type of quick-break knife switch which can be supplied with carbon break, and which is specially suitable for feeder panels. Their Mordey patent fuse is also especially suitable for traction work both on feeders and for lighting circuits. One form (for car work) will break on a 550-volt circuit without any destructive arc or damage to terminals.

The Laconia Car Company Works, of Boston, U.S.A., supply a type of car and truck especially adapted for high speed inter-urban service, which can be run as fast as 40 miles per hour. This car is built on steam car lines, with straight sides, roof with monito full length over vestibules, equipped with hand and air brakes, and having cross reversible seats (for 40 passengers).

The "Stewart" series running enclosed arc lamp, supplied by the Stewart Electrical Syndicate, Limited, 57, New Compton Street, W.C., was specially designed for the purpose of enabling it to be run five in series on a pressure of 500 volts, direct current, which is the E.M.F. most usually adopted for the operation of electric trams and railways. The problem to be solved in this case was not simply to produce a current regulator which should work with freedom and steadiness, feeding forward the carbon with regularity, but also to find one which would stand sudden and extreme variations in line pressure. After much trial and failure, an altogether unique form of regulator, which may well be called the "parallel ruler" principle, was adopted. With this movement the upper carbon is fixed in a holder, at the upper end of which is a wheel just too small in diameter to be gripped between the two parallel rods. These rods are linked together at both ends, in the same manner as the two sides of a parallel ruler. The bottom link is extended in one direction to carry the core of the series solenoid, and in the other to form a tailpiece which, by resting on the base plate of the lamp, forms a fulcrum on which the link turns so as to spread the rods apart. The action is as follows:—On the current being turned on, the solenoid attracts its cores, and raising one side of the parallel ruler, grips the wheel of the carbon holder between the two rods, parting the carbons, and continues to rise until the current strength for which it is adjusted has been reached. As the carbons burn away and the current tends to decrease, the shunt solenoid over powers the pull of the series coils and the feed takes place in the ordinary manner. Of course, in a circuit subject to violent fluctuations of pressure, this action could not take place if the lamp was arranged to feed very closely to either the agreed amperes or volts on the arc; but by carefully apportioning the windings of the two solenoids, a lamp, not perhaps as perfect as might be wished from a laboratory point of view, is obtained which will not jump under the variations met with in traction practice, but in which, on the contrary, the positive carbon will rise and fall gently and continuously with every variation of pressure on the circuit, and after all it is under conditions of actual practice rather than those which obtain in the laboratory and testing room that a lamp should be on its best behaviour. The ordinary form of inner bulb trimming is often used, but it has been found that sufficient care is not taken to render the joint airtight, and any want of parallelism in the grinding of the top edge of the bulb tilted the cover on one side and tended to jam the upper carbon where it passed through the hole in the bulb cover. To obviate all these defects the lamps are now, when so ordered, provided with the trimming device adopted by the same firm for their "Continental" lamp, which we have previously noticed in these columns. Here the bulb cover is no longer loose, but forms part of the body of the lamp, and is therefore always rigidly at right angles to the line of the carbons. The inner bulb itself is completely closed at the bottom and is quite independent of the carbons, which can consequently be got at and trimmed with the same facility as in an open-type lamp. The bottom of the bulb is engaged by a cap, forming the lower end of a swinging bail, which, being hinged in one direction only and pivoted slightly out of the centre, has only to be pressed back into position, when it not only forms an elastic cushion keeping the upper edge of the bulb constantly pressed against the faced surface of the cover, but also an absolute lock, out of which it is impossible for the bulb to fall. The lamps are supplied by the Stewart Electrical Syndicate, Limited, of 57, New Compton Street, London, W.C.

Messrs. Belliss & Morcom, Limited, of Ledsam Street, Birmingham, whose patent self-lubricating, quick revolution engines are being largely used in English tramway and lighting stations, have sent us some lists and details relating to their work. Their engines are doing service, as our readers are well aware, in the Waterloo and City Electric Railway power station with Siemens generators, at Halifax lighting and tramway power house with E.C.C. generators, and at other places, with Crompton and Bruce Peebles machines.

Messrs. Isenthal & Co., of 85, Mortimer Street, W., are supplying electric heating apparatus (under the Schindler-Jenny patents) for tramcars, yachts, and other vessels. An illustrated list is in circulation.

There is an increasing demand at the present moment for a reliable enclosed arc lamp for use on traction circuits, which will not be affected by vibration, and will burn steadily under extreme variations of pressure, and at the same time will burn the maximum number of hours, viz, 100 to 200 hours, and give the minimum trouble to recarbon with the consequent least interference with street traffic. Messrs. Johnson & Phillips, of Old Charlton, Kent, claim that their enclosed "Ark" lamp possesses simplicity of design, steady burning, freedom from repairs, and low cost, both initially and for maintenance. The lamp is complete in itself, and there are no external resistances or cut-outs required, these being placed inside the lamp case, thereby greatly reducing the cost. A description of the lamp appeared in our issue of November 22nd. The cut-out is of simple and reliable design.

The "Ark" lamps are now extensively used for street and combined traction lighting, including East Ham, Barnsley, Mexboro', Sutton Coldfield, Chester, &c. Those at East Ham (about 150 in number) are suspended on the brackets carrying the trolley wires, and subject to extreme vibration from the passing cars, which, however, we understand, does not affect their proper working in any way.

ELECTRIC TRACTION NOTES.

Darlington.—The T.C. has decided to construct and work municipal electric tramways, and to borrow £100,000 for that purpose. The question has been under discussion over two years, and the voting for municipalisation last week was 17 to three against.

Dublin.—A young girl, named Kate Thorpe, while trying to cross in front of a tramcar at Queen's Street, last Monday week, slipped and fell. She was caught by the netted guard of the car, and carried for some way on it before the car could be brought to a standstill. She was not injured in the slightest degree.

Glasgow.—It is proposed to extend the Anniesland route further west, so as to meet the Dumbarton Road about Scotstownhill district. The drawings for the first six months of the financial year, commencing June 1st, have now been made up, and amount to £327,319 4s. 5d., compared with £244,269 12s. 11d., for the same period last year, an increase of £83,059 11s. 6d. The increase is partly accounted for by the fact of increased traffic, due to conversion to the electric system and quicker service and also to the exhibition.

Havana.—A great deal of special work was required in Havana's new trolley line. We read in New York *Electricity* that while some of the streets are broad and spacious in the Cuban city, other streets traversed by the cars are exceedingly narrow. The trolley wire supporting pole on one side of a narrow street is attached to the house, owing to lack of space for its location on the curb line. These poles are of pipe, built to form trusses. Two trolley poles on the car are necessitated by the overhead return system adopted, it being feared that the use of the rail would be unsatisfactory for this purpose during the dry season.

Keep the Wheels Turning.—Whenever electric cars have superseded steam or horse cars, the headway has been decreased invariably, generally by a considerable amount, and the mean speed has beensomewhat increased. It is very noticeable, however, that in many places some difficulty is found in breaking away from old traditions.

For instance, a more or less lengthy stop is frequently made at termini. Under the hay and steam *régime* this was absolutely necessary. The hay-motor is the only motor that gets tired, and requires changing after short periods of running; consequently, stops of some duration have to be made to exchange teams at the termini or depôts. Always the horses have to change ends for the return journey. Similarly, the fires of a steam tram engine have to be cleaned and fired up at termini, and water has to be taken frequently. The time occupied in these operations, and in getting right end foremost, may not be very long—generally five minutes or so—but even a few minutes multiplied by the number of trips per day, multiplied by the number of cars, will total up to a good round figure in time, which time has a known value for every tramway.

There is no reason whatever for these delays with an electric service. When a terminus is reached, the car is ready to return directly the conductor has swung the pole round, and the driver has changed ends. One minute is ample time to allow for these operations (the slowest conductor will find himself able to light the forbidden cigarette after having found the wire). On a really quick service, of course, one minute could not be allowed, but on headways of less than five minutes, time is never wasted.

So many managers have an objection to starting from a terminus at odd times that they waste considerable time in standing at either end, simply in order to leave at an even indication of the clock.

For instance, with a 20 minutes' service it is most convenient to start at the hour, 20 minutes past, and 40 minutes past. This arrangement obviates the necessity for complicated time-tables, and is likely to be appreciated by the public; but it may be bought too dearly.

Taking a hypothetical case:—Say the route is five miles, average speed, including stops, 6 m.p.h., therefore time taken over round trip = 100 minutes. It is decided to run a 20 minutes' service with five cars, and the published time-table states that cars leave at the hour, and every 20 minutes after. On this service the price paid for beautiful uniformity is 20 minutes per round trip run. If each car does 11 trips per day, the total time lost is $11 \times 5 \times 20 = 1{,}100$ minutes. Giving each of these minutes the value of 3d.—not an extraordinary value—the total money loss comes to £13 15s.

Of course this is an exaggerated case—although we have actually seen worse—but it will serve to bring home the great value of keeping the wheels turning, even at the expense of circulating time tables, and accepting the risk of a certain amount of grumbling from a few folks who "can't understand why the trams don't run at proper times."

The power station is interested in the matter to a considerable extent—passively—as the plant load factor is dependent on the use factor of the running cars.

Every endeavour should be made to obtain the maximum number of car-miles in the least number of car-hours, then there will be economy all round.

Maritzburg.—A report by Mr. J. Vincent upon the electric lighting and tramway stations visited by him, during his recent visit to England and Scotland, was lately forwarded to the local Town Council.

Cape Town.—The extension of the electric tramway from Sea Point to Camp's Bay has been completed, and the line is now open to traffic.

Isle of Thanet.—The Isle of Thanet Electric Tramways and Lighting Company has this week been before the public inviting subscriptions for an issue of £150,000 4 per cent. debenture stock, and 30,0 0 5 per cent. £5 preference shares. The list was to close yesterday (Thursday).

Liverpool.—The new bye-laws affecting the working of the Liverpool electric tramways were adopted at the monthly meeting of the Liverpool City County Council last week. It was stated by Councillor Lloyd, during the meeting, that the Tramways Committee would construct a new line of tramways from Walton to the north docks and Bootle as soon as an arrangement could be come to with the Bootle Corporation, as part of the line would be within the borough of Bootle.

Shipley.—As the Bradford Corporation and the Shipley D.C. have come to what seems like an absolute deadlock in regard to terms in respect of the Saltaire section of line passing through the Shipley district, there is no prospect at present of the conversion of this section to electric traction being simultaneous with the conversion of the remainder of the Bradford tramways.

Strange Behaviour of Bonds. — Bond-stealing, a flourishing profession in America, used to be so serious on the Baltimore and Ohio belt line that, when new rails were laid recently, the exposed bonds were replaced by flexible copper bonds under the fish-plates; thereby the thief has been circumvented, but the position of the company seems to be almost worse than before, if one may judge from the illustrated article that appeared in the *Street Railway Journal* for November. The photographs reproduced are most interesting, and disclose a pitiful, and probably unique, state of affairs. It appears that extraordinary care was exercised in applying the bonds, yet, when tests were taken a few weeks after on some of the joints, they showed a resistance equivalent to 10 times an equal length of continuous rail. On some sections of the line the copper was squeezed out between the fish-plates and the head of the rail, in sheets of about ·005 in., after only a few days' running. Everyone appears to be non-plussed as to the cause of this phenomenon, and, without intimate knowledge of all the conditions, it is difficult to suggest any solution, except the springing and compressing action due to the frequent passage of the 97-ton locomotives over the joints. The gentleman who supplied the photographs also supplies a column of recommendations for applying protected bonds on such lines, but none of them appear to contain the remedy for the defect noticed. Perhaps it would pay the line better to revert to the open bond, and patrol the line with men and dogs.

Trolley Wire Poles.—There is no doubt that a tube is not the best mechanical form to withstand the stresses met with in span-wire work, but it has been proved by actual experience that no other form is so sightly. Built-up poles can be made lighter, stronger and cheaper than pipe poles, but who would have them in the streets? As a matter of fact, they are to be seen in the streets of some Continental cities, and very ugly they look. Appearances are not considered before the pocket in the States; and Mr. John Lanz, of Pittsburg, Pa., has designed and patented several forms of built-up poles, which are described and illustrated in the *Street Railway Review* of October 15th. Mr. Lanz proposes to make—it is not stated that his system has "materialised" as yet—every third, or sixth, pole latticed, and to use, intermediately, 9 in. I beams, loaded in the direction of the web. The stiffening poles can be built in a triangular or in an approximately circular form. The triangular arrangement gives the greatest strength with the least steel. It is stated that the weight of a mile of pole work on this system, with every sixth pole latticed, is to the weight of a mile equipped with 8-in. pipe poles, as 7 : 11, and that the cost of manufacturing is only one-quarter of the cost of pipes. If these figures are correct, and royalties were not excessive, such a system might be used to advantage on country lines, or on private rights-of-way; but we should first of all inquire as to the validity of the patents, and then as to the particular reason for the extra strong poles at intervals.

Underground Railways.—Mr. G. M. Freeman, K.C., at a sessional meeting of the Auctioneers' Institute of the United Kingdom, held at the Examination Hall, Victoria Embankment, last week read a paper on the "Problem of the Tubes," discussing the rights of property owners. Mr. Freeman confined his remarks to the various questions which are likely to arise, or have arisen, between the promoters of underground railways and owners of adjacent property. He said the prophecies put forward by eminent engineers when the South London and Central London Railways were being promoted, that no possible damage could be caused to adjacent buildings, had not been wholly verified. Dealing with the legal rights of a landowner in cases where no land is taken, but his property is alleged to have been damaged, Mr. Freeman said if he could show that the construction of the works had physically injured his premises, as by cracking his walls, jamming his doors, or lowering his drains, he could obtain compensation for injurious affection. And this no doubt was usually the cause of the damage. Anything arising during construction, Mr. Freeman observed, was the proper subject of compensation. Mr. Freeman said the question of the right of landowners to be heard before Committees of Parliament on the construction of an underground railway is at present very uncertain. Owners of sub-soil were, of course, entitled to a general landowners' locus, but others whose lands might be affected, though not taken, would probably be excluded. They should all equally be entitled to lay their views and fears before Parliament.

Glasgow Engines.—At last week's meeting of the Corporation, Bailie Ferguson asked the convener of the Tramways Committee if it was the fact that the American engines for the electric cars were delivered before April in good time for the summer work, and that the British engines were not in time to start till September 23rd; also, if, without the American engines, there would have been no summer service except the 70 or 80 cars worked by the Stewart engines and the Springburn power, dovetailed between 200 to 300 horse cars, and if they would have been without the £60,000 or £70,000 earned during June, July, August, and September by the Allis engines. In reply it was stated that the work was done by the Stewart engines and the Springburn power in May before the American engines were ready, and very effectively done so far as it went. The offers for the Musgrave and American engines were accepted at the same time.

Grimsby.—The electric tramway service was opened on Saturday morning without any ceremony. The system is owned by the Provincial Tramways Company. A brief description has already appeared in the Electrical Review.

London.—At Tuesday's L.C.C. meeting the adjourned report of the Highways Committee, to which reference was made in our last issue, recommended the Council to approve the adoption of the underground conduit system on the six tramways specified a week ago. With regard to the exclusion of the New Cross Gate—Greenwich line from the scheme, the Committee now explained that this was due to the difficulties of placing electrical conduits in the carriageway of certain bridges which carry the tramway lines over railways. The question of surmounting the difficulty was being considered, and the committee proposed to report again on the matter as early as possible and to recommend the Council to proceed with this section. No discussion took place on the committee's recommendation in regard to the six lines which were approved for the conduit system.

Margam.—The Margam (Glamorgan) U.D.C. has postponed the consideration of the question of constructing an electric tramway from Taibach to Aberavon.

Middleton.—It has been decided by the T.C. to offer to the Manchester Corporation, in respect of the Middleton Corporation tramways and the Middleton and Chadderton tramways, the same terms as had been agreed upon with the B.E.T. Company for the supply of current for the Middleton Light Railways.

Oldham.—The first fatal accident in connection with the electric cars occurred the other day, and the Tramways Committee have decided to fix one of the latest kind of lifeguards to all the cars. The surveyor has presented a report upon the work already done in connection with the reconstruction of the tramways. Work was proceeding on three different routes in sections, but owing to lack of workmen—principally platelayers—and the slowness with which material was coming in, the progress was not as satisfactory as was desired. Then, again, very bad weather had hampered them considerably.

Perth Tramways.—The T.C. has decided to acquire by arbitration, the system of the Perth and District Tramways Company.

Romford.—The U.D.C. is going in for electric tramways. Mr. Hawtayne has submitted three separate schemes for consideration. (1) Combined lighting and traction, cost £45,337; (2) tramways, independent of lighting, £50,487; (3) providing permanent way and overhead equipment for four lines, feeders in the Council's area, but not including cars or station plant, cost £36,187. The matter was discussed by the Council on Thursday last week, and there was a good deal of opposition.

Street Railway Construction.—There was a crowded attendance at the meeting of the Institution of Junior Engineers on December 6th, held at the Westminster Palace Hotel, the paper read being on "Street Railway Construction for Electric Traction," by Mr. F. S. Pilling (member), of Devonport.

Sutton.—The plans of the proposed British Electric Traction Company's lines have been deposited, and the routes have occasioned some hostile criticism in view of the narrowness of certain thoroughfares. The printed minutes of a special Council meeting held *in camera*, show that the chairman and the surveyor had interviewed the company's engineer with regard to the company's Bill, and after discussing various modifications the heads of an agreement had been drawn up; these had been duly discussed. Discussion also ensued on the offers by the company not to construct certain possible extensions without the consent of the Council, the chief lines being to Belmont and along Brighton Road. After a somewhat contentious debate in open Council, tramway matters were referred back for further consideration.

Wigan.—A curious accident occurred on Saturday night in connection with the construction of the new electric tramway from Wigan to New Springs. Three men, named Hill (a foreman), J. Holden, and R. Lester, were working on a pole-planting wagon at Scholes Bridge, and were in the act of erecting a large iron pole, when the tower portion parted company from the body of the wagon and toppled over, the men being precipitated on the other side of some hoardings, and just missing falling into the river. Hill escaped unhurt, but Holden and Lester were so severely injured as to necessitate their removal to the Infirmary.

CONTRACTS OPEN.

(*Continued from page* 968.)

Barnstaple.—January 16th. Boilers, engines, dynamos, mains, &c., for the Town Council. See "Official Notices" to-day.

Hammersmith.—December 18th. Mains, service cables, &c., for the Council. See "Official Notices" to-day.

Monmouth.—The E.L. Committee recommend that extra plant be purchased and fixed at their generating station, but above the level of floods.

Nantwich.—January 6th. Water-tube and Lancashire boilers, c.c. steam dynamos, pumps and piping, switchboard, mains posts, battery, meters, crane and dust destructor for the U.D.C. See "Official Notices" November 22nd.

Oban.—December 18th. Three 60-kw. steam dynamos, two water-tube boilers, economiser, &c., for electric lighting. See "Official Notices" November 29th.

Pontypridd.—December 14th. Water-tube boilers, stokers, economisers, steam engines, dynamos, balancer, switchboard, workshop, crane and arc lamps, for electric power station. See "Official Notices" November 22nd.

Reading.—December 28th. Water-tube boilers, economiser, pumps, engines, condensing plant, generators, switchboard, crane, motors and car equipments, car bodies, trolleys, &c., for the Corporation. Borough engineer's office, Town Hall. Specifications, &c. (10 guineas).

Roumania.—December 30th. Tenders to the Roumanian Post and Telegraph authorities in Bucharest, for the supply of 5 tons of bronze wire 1½ mm. diameter. Tenders are to be sent to La Direction des Postes et des Télegraphes, Bucharest, whence particulars may be obtained.

Southampton.—December 14th. Electrical equipment of printing and other machines in the Ordnance Survey Office, Southampton. See "Official Notices" November 22nd.

Stepney.—December 18th. Generating plant and wiring at the Stepney Union Children's Homes, Stifford, Essex. Consulting engineers, Dolby & Williamson, consulting engineers, 8, Princes Street, Westminster, S.W.

Sunderland.—December 20th. Cast-iron pipes and copper piping, valves, &c., for electric light station. See "Official Notices" December 6th.

Wakefield.—December 21st. Cables and street transformers for the Corporation. See "Official Notices" to-day.

Warrington.—December 31st. Electric light mains and fittings at the tramways car depôt for the Tramways Committee. See "Official Notices" to-day.

West Ham.—January 14th. Surface condensing plant and travelling crane for the electricity works. See "Official Notices" to-day.

Wolverhampton.—December 20th. Two-phase motor-generators, boosters, switchboards, and battery, for Midland Electric Corporation. See "Official Notices" December 6th.

CLOSED.

Batley.—The tender of Messrs. Clayton, Son and Company, Hunslet, for the supply and fixing of boilers, pipes &c., at the electricity generating station, has been accepted by the Batley Corporation.

Bournemouth.—Last week the T.C. accepted the tender of Messrs. W. E. Jones & Son, Bournemouth, for car sheds at £7,748. The tender of Messrs. Jenkins & Sons, Bournemouth, for an engine house, at £11,719, was also accepted, and that of Alphons Custodis Chimney Construction Company for the chimney at £1,215.

Croydon.—The E.L. Committee, having considered tenders for balancer sets and switchboard at the electricity works, and for the construction of an underground sub-station in Addiscombe Grove, recommended the Council to accept the following:—Messrs. Siemens Bros., Limited, balancer sets, £1,015; switchboard, £258. Mr. F. Atbey, South Norwood, sub-station, £97 15s. The report was adopted.

The Lunacy Visiting Committee have invited tenders for the supply of generating plant, storage battery and switchboard in connection with the electric lighting of the asylum, and recommended that they be authorised to accept tenders, and to enter into contracts accordingly. The report was adopted.

G.W. Railway.—The St. Helens Cable Company, Limited, of Warrington, has secured a portion of the Great-Western Railway Company's contract for india-rubber goods.

Leyton.—The Electrical Committee of the D.C. has given a contract in connection with the electric lighting installation to a German firm. The difference in the estimates was £244.

Mansfield.—The Council on 22nd ult. accepted the following tender for refuse destructor:—Messrs. Heenan & Froude, £5,068 5s. 0d.

New Cable.—A correspondent informs us that an order for the laying of the first section of the new Pacific Cable from San Francisco to Hawaii has been received by the Silvertown Company.

Newport (Mon.).—The Electricity Committee, acting upon a report by Mr. Parshall, their expert, recommend their Council to accept the following tenders for various sections of work in connection with their new electric tramways:—

Sir Hiram Maxim & Co., steam piping	£2,885	0	0
The Britannia Company, switchboard	1,091	10	6
W. T. Henley's Telegraph Works, Limited, cables ..	3,874	10	1
Callender Cable and Construction Company, cable ways	3,514	19	6
* W. T. Glover & Co., overhead construction	7,937	3	7
† British Westinghouse Company, 30 electric motor cars	14,424	10	0
Newbold & Co., repair shop equipment	825	0	0
	£34,502	13	8

* The tender of Messrs. Glover & Co. is recommended for acceptance subject to all detail work in connection with the contract being specially approved, and to the Corporation having the option to extend the contract, so that any extensions of the tramways may be served by the same.

† The tender of the British Westinghouse Company is recommended for acceptance subject to approval of design of car by persons appointed by the Council.

Mr. Parshall reported that the tender for the steel chimney shaft, and also that for the outside coal-handling apparatus are being held in abeyance, the former pending the receipt of the tenders for the building work, and the latter as he had decided upon a modified arrangement so as to afford a greater convenience in dealing with the coal supply. Mr. Parshall also reports that the total amount of the plant and works for the complete equipment of the power house and car shed, line work, distributing system and rolling stock, comes to £105,076 6s. 4d., which may be sub-divided as follows:—

Contracts already placed	£42,773	12	8
,, recommended	34,502	13	8
Estimate of work remaining to be placed	27,800	0	0
	£105,076	6	4

Wimbledon.—We stated last week that the contract for wiring the electricity works extensions had been given to Mr. G. W. Clarke. We learn, however, that this is incorrect, the contract having been given to Messrs. Tamplin & Makovski, of Redhill and London.

Wolverhampton.—The T.C. on Monday accepted the tender (£523) of the Electric Construction Company, for certain electrical machinery required for new cold stores.

FORTHCOMING EVENTS.

Friday, December 13th.—At 5 p.m. Physical Society of London. Meeting at the rooms of the Chemical Society, Burlington House. Paper "On Circular Filaments and Circular Magnetic Shells equivalent to Circular Coils, and on the equivalent Radius of a Coil," by Prof. Thomas R. Lyle.

At 8 p.m. South-Western Polytechnic, Chelsea. Distribution of prizes and certificates by Prof. Rücker.

Tuesday, December 17th.—At 7.30 p.m. Institution of Electrical Engineers (Manchester Section). Meeting at Owens College. Paper by Julius Frith, A.M.I.E.E., and E. H. Lamb, B.Sc., on "The Breaking of Shafts in Direct-Coupled Units caused by Oscillations set up at Critical Speeds."

At 8 p.m. Institution of Civil Engineers; meeting. Paper to be discussed, "Motive Power from Blast Furnace Gases," by Bryan Donkin.

Thursday, December 19th.—At 7.30 p.m. Institution of Electrical Engineers (Dublin Local Section). Meeting at the Royal College of Science, St. Stephen's Green, Dublin. An address will be given by the chairman, Prof. W. F. Barrett, F.R.S.

At 8 a.m. Institution of Electrical Engineers. Adjourned discussion on Paper on "Some Principles Underlying the Profitable Sale of Electricity," by A. Wright.

Friday, December 20th.—At 8 p.m. Institution of Civil Engineers. Students' meeting. Paper on "Transmission Dynamometers," by A. M. Morgan.

The Underground Arbitration Award.—We learn that the Hon. A. Lyttleton, K.C., has presented his report to the Board of Trade in regard to the system of electrical working to be employed on the Metropolitan and District Railways. It is in favour of the continuous current system advocated by Mr. Yerkes.

NOTES.

Please Take Note.—The issue of the ELECTRICAL REVIEW for December 27th will, on account of the Christmas holidays, be published on the morning of the preceding Tuesday. Will our friends kindly take notice, therefore, of the following, as the very latest dates upon which matter can be received for insertion in that issue:—

Correspondence, Notes, Business Notices, &c., on *Saturday, December 21st.*

New advertisement copy and alterations to existing advertisements, *Friday, December 20th.*

Official Notices and small prepaid advertisements by noon on *Monday, December 23rd.*

The Gong. A Study in Exclamations.—So, sleeping in the cosy corner of the car, a dream came to me; and, in that dream, my soul took unto itself the outward form of the sonorous car-gong, full-toned, commanding, hidden from common gaze, but seeing all.

"Dong!" says the gong, answering the little brother, treble-voiced, speaking from above at the touch of the conductor. "Off again! Hurrah for the road!"

"Dong-dong! get out of the way. Avoid thee, O wagon! Clear the track for my flashing car! Will you still hold the way? Dong-dong! I say, thou great lumbering eater of time! . . . Nay, good waggoner, if such is thy talk my driver must answer thee, the while I stop my ears."

Away once more, and the track clear save for light-running and obedient traps. Who's this jumps on? An inspector? Yes! and another car in sight. Quick, driver, quick! the signal; two taps and one. Out goes my voice:—"Have a care! Smoke not, O driver! nor drive at speed. O conductor! see to thy fares, thy waybill, and thy cash, that they tally the one with the others; keep keen outlook on either side, and let not the whip of authority scourge thy back!"

Passed in safety, with a warning cry, gong to gong, to save him who might step across our track from behind the receding car.

Three times calls the little brother. "Full up," says he. Now let us go, let us run without stop, till a tight-squeezed passenger alights.

Ah! how near! and I not able to speak, so suddenly did the careless carter swerve into the track, the sacred track! Luckily a dry, good rail, or the emergency, hastily snapped on, would hardly have saved us. "*Now* driver, while I seal my ears!"

Ugh! into the fog, heavy and evil-smelling. Now for the dismal funeral voice ever declaiming! What a feeling of fear overcomes me as the car slows into the gloom! How much depends on the clearness of my voice, and the eye of the driver, who nervously fingers the brake. (Can I not see the chain coming and going beside me!)

"O driver! hasten! A light ahead, quickly coming! Ho! release my voice. What! the striking plunger stuck? Quick, brave man, nor lose thy head! Lives, maybe, depend on thy alertness. Loosen the plunger, send out my imploring, warning voice, and on with the brakes! Well done! Well done. brave man!" Slower, and slower still. Ah great God! too late. "Reverse; send her back!" 'Tis another car! A car driven carelessly by a blind driver! . . . "It comes apace, Save thyself! I stay here; dumb, but having done my duty!" . . .

I woke, thrown into the pell-mell of passengers, before I understood. Luckily only a few bruises, a little blood, and a fainting woman. What of the car? Alas! car and meeting car combined, intermingled; platform of one on platform of the other; all parts mangled! And the gong? Pity for the gong! Lifeless, tongueless, toneless, it lies; shorn off and broken by the cruel bumper! An agonising sight!

Electric versus Cable Traction.—When mechanical traction systems first really became seriously discussed, and the horse recognised as an inefficient and undesirable means of moving tramcars, our well-known and generally-speaking much-to-be-lamented British inertia, or resistance to change, gave rise to one considerable advantage. We did not in this country spend enormous sums on the equipment of entire tramway systems in the big towns and cities for operation by means of cables or endless wire ropes. This was done to a considerable extent in the United States, both prior to the introduction of reliable electric systems, and also afterwards, where special reasons made it easy for the cable engineer to get full sway. The consequence has been that a large number o cable lines in the United States were put in for a few years only their limitations being soon found out, and their advantages seen t be much less than of those worked by electricity.

In this country, however, we progressed with characteristic slowness, and thereby escaped wasting a great deal of unnecessary capital outlay on cable roads, seeing that by the time the tramway companies themselves, and the local authorities concerned, had waked up to the fact that the horse, or "corn motor," was out o date, electrical engineers were right on the spot with a reliable and economical overhead trolley-wire system, possessing far greater advantages than the cable could give. Consequently, one may almost number the cable roads or systems in this country on the fingers of one hand; in fact, we, believe, that there are practically *just five* of the kind, viz.: (1) Highgate Hill; (2) Edinburgh; (3) Birmingham (4) Brixton Hill; (5) Matlock. In each case the primary reason for installing cable working has been the existence of more or less steep grades; but it may be said with

assurance that electric cars could quite well climb these grades, and go down them, too, with ease, economy, and safety—to judge at least from what has been done in other places. Possibly the cable has some justification on Highgate Hill and at Matlock, though even in the former case the cable itself should be operated by an electric motor or motors, with cable dummies on the road, by means of which electric cars from connecting roads can be taken up, and so save changing cars; and on the latter line traffic must for a long while to come be of so slight and unimportant a nature, that it hardly seems worth while keeping a cable constantly on the run when one car every 15 or 20 minutes serves to carry all the passengers that want to travel. As for the other three lines, the grades encountered on them are not at all excessive for electric cars; and it will probably be only a very short time until the cable is taken out of the Brixton Hill route. Such a grade is no obstacle at all to electric cars of a modern type, and the traffic manager of the united South London tramway system may be trusted to sufficiently emphasise the absurdity of having one cable section (and that one a most important main line connecting London with Croydon) when all the rest is, or will be, electric.

There was more justification for installing a separate cable road in Birmingham, especially as it was done when the tramways of the district were already in several hands, and the grades to be traversed were of a more severe nature; the traffic, too, promised to be very heavy, such as would fully justify the frequent service of cars, which can alone be given with economy on a cable road; and the line was, moreover, self-contained, in so far as it gave access to and from the heart of the city—being very different in this respect from the Brixton Hill line, to which there are long connections from the City termini a couple of miles distant. It seems, however, not unlikely that even the Birmingham cable road may—on the final unification of the district lines in the hands of some one interest, either company or municipality—either be replaced by an electric line or continue to be worked as a cable road by means of electric power, as already suggested in connection with the Highgate Hill line.

The last of the cable lines mentioned herein—viz., those of Edinburgh—are perhaps of special interest now, in view of the controversy going on between the local authority and the tramway company in regard to the running of Sunday cars, and even more in regard to the very existence of the tramway company itself, which, owing to the onerous terms imposed upon it by the Edinburgh Corporation, finds itself on the verge of bankruptcy. The cable was first introduced into the district by the Edinburgh Northern Tramway Company, to work a route on which there was an admittedly steep grade. As this line tapped the heart of the city, represented by the middle point of the famous Princes Street, there was perhaps no serious objection to the cable remaining here as the motive agent, or even to extending it on the north, so as to run into the Trinity district of Leith. But to equip the whole of the Edinburgh lines—most of them on fairly level roads—for cable working, was a piece of madness for which probably not merely the unfortunate working company, but the Corporation also will suffer very heavily. Of course, the primary and ostensible reason was the alleged impossibility of allowing a city of such æsthetic pretensions as Edinburgh to be disfigured by overhead trolley wires; and the worship of this fetish has meant the expenditure of £1,250,000 in the equipment of, say, 25 miles of double track, equal to £50,000 per mile of double track. It does not seem to have entered into consideration that a city of some 250,000 could hardly furnish traffic sufficient to justify such an outlay; but so long as the Edinburgh Corporation could come down upon the lessee company for 7 per cent. upon the capital outlay as an annual payment for rental, what need they care whether the receipts allowed such a payment or not? As a matter of fact, it was directly in the interests of the Corporation to spend as much as possible, seeing that they could borrow at from 3 to 3½ per cent., so that after allowing for depreciation and sinking fund, equal altogether, say, to 5½ per cent., there remained 1½ per cent. clear profit to the Corporation so long as the company could pay up. But with gross annual receipts of, say, £150,000, and working expenses of £95,000, how on earth could the lessee company pay out of the £55,000 surplus, firstly, 7 per cent. on over a million pounds to the Corporation; secondly, depreciation and sinking fund contribution in regard to its own capital; and thirdly, something by way of dividend to its shareholders? Small wonder is it that in a last despairing effort to struggle against this overwhelming task, the Tramway Company should have rebelled against sacrificing one-seventh of its possible income, and started Sunday cars in the face of opposition, not merely from the Corporation, but also from the "unco' guid," who are not altogether unknown in Scotland.

It is, of course, neither proper nor profitable to discuss here the question of Sunday cars from the religious standpoint; this may be left to the correspondence columns of the daily newspapers, where, as a rule, more foolishness than wisdom may be seen. At Edinburgh apparently the question has been decided purely on its legal aspects, and this is just as well. The law, as administered in this country, is apt to take a broader view of public matters in dispute than will, perhaps, satisfy either party, but the results are, on the whole, such as ultimately prove best. Even granting Sunday cars to Edinburgh, however (as was done last week), it is more than doubtful whether this will save the position for the Tramway Company. In spite of all the claims put forward on behalf of the cable in regard to economy of working, it has proved, on an extensive network like that of Edinburgh, so productive of breakdowns and difficulties, owing to junctions, &c., and has led to such a serious reduction of speed when it *does* work, that probably the available surplus revenue over and above working expenses will not, for the whole period of the lease, provide anything like enough for rental, depreciation and sinking fund, let alone dividends for the shareholders. A reasonable man would say at once that the Corporation for a good long term of years should be content with receiving a smaller rental—sufficient to cover all charges and leave a small balance. Probably 5½ per cent. would be ample for this, and would relieve the company of a payment equal to £15,000 or so.

To our mind, the proper course to pursue is of a more drastic nature, and one requiring such a strong man or body of men to carry through locally, as Edinburgh does not seem to be blessed with. There is not the least doubt but that a mistake has been made in putting in the cable throughout, and the sooner this is admitted the better for Edinburgh and its tramways. Electric traction alone will give the services required, and if the good people of Edinburgh think so highly of their somewhat dingy, if grand, streets as to forbid overhead wires, then they must take out the cable and instal an electric conduit system, except, perhaps, on the original Edinburgh Northern line. They must boldly write off as lost capital so much of the money spent on the cable system as will be unproductive under the use of electricity; and they should then in all fairness come to a new arrangement with the present tenant of the lines whereby the latter may not only have a chance to give Edinburgh what it never has had—a complete and successful system of mechanical traction on the street tramways—but may also be in a position to join in putting an end to the disgraceful exhibition of municipal jealousy between Edinburgh and Leith, which has led to the still existing absurdity of passengers from one place to the other, over a road two or three miles long, having to change from one car into another at the boundary.

This latter point has not been touched upon at all in detail, but it is bound to have a very great indirect effect upon the question of Edinburgh tramways, having in mind the fixed determination of Leith in favour of electric traction; and in all probability we may yet see in this district another instance of the way in which sometimes the tail wags the dog.

Wheel Wear on the Boston Elevated.—"A Western contemporary in the electrical field asks, 'What is the matter with the steel used in the track and contact rails on the elevated road of Boston?' Some months ago we took occasion to comment on the peculiar conditions that have arisen since the starting of the elevated lines in Boston. That there is an immense amount of iron and steel dust in the vicinity of the elevated tracks is a matter of common knowledge. This might lead anyone who reads the reports at a distance to inquire as to the composition of the steel in the track, and to pronounce it faulty, as our Western contemporary has done. Unfortunately for our contemporary's assumption, this is not borne out by the facts known to those on the ground. The unusual amount of noise caused by the trains on the Boston Elevated, as well as the unusual amount of iron dust, is a matter well known to the residents of that city. The cause for this noise is found to be the peculiar way in which the wheels wear. A train of cars, equipped with new wheels, is said to run as noiselessly as on any elevated road. After the cars have been in service for some time, however, a number of flat spots, about one-fourth the size of a man's hand, appear on the chilled tread of the wheel. It is to the presence of these flat spots that the great amount of noise is due. What causes these is a matter which is puzzling the elevated railway officials. It has been determined that the flats are not due to any sliding of the wheels, as men have been detailed to watch this carefully for weeks at a time. The equipment of the Boston Elevated, as to tracks and wheels, is the same as that of other elevated roads in this country, with the exception that the difference between the wheels and track gauge is only ⅜ of an inch, which is somewhat less than on other roads. It is possible that this causes a pinching on the curves (and the curves are very numerous on this road) which causes the peculiar wheel wear. The wear on the track would also seem to indicate this. There is one other respect in which the Boston equipment differs from any other, and that is in the use of right and left-hand motors, so as to bring the gears on a track on the same side, instead of on opposite sides, as is usual. One theory is, that this arrangement slightly unbalances the truck, so as to cause the unusual wheel wear, but this has not been demonstrated as yet. Taken altogether, the situation is a peculiar one, but it is not one upon which it is safe to theorise at a distance."—*Street Railway Journal*, Chicago.

Electric Tramway Practice.—On November 29th Mr. P. T. J. Estler, A.M.I.C.E., read a paper on "Recent Electric Tramway Practice in the British Isles," to the University College Engineering Society, London. He confined his remarks exclusively to the overhead trolley, and dealt more especially with standard practice. The paper was divided into the following headings:—Track, Overhead Equipment, Generating Station, Switchboards, Cables, Cars and their Equipment. In regard to track work, the author laid special emphasis on the importance of good workmanship and careful supervision. The divergence in the methods adopted, and section of rails, and, worst of all, the variety of gauges used was deplored—every corporation and company apparently laying its track without considering future demands of interurban communication. The overhead equipment was fully dealt with, and the folly of economy in this part of the system demonstrated. Emphasis was laid on the importance of designing the generating station for future requirements, and in such a manner that the extensions are symmetrical with the first instalment. Cars and their equipment were treated in detail. The pneumatic slipper brake of Hewitt & Rhodes was considered the most efficient in use at present, more especially as it has all the essentials of an emergency brake. The paper was illustrated by numerous lantern slides, photographs and drawings.

Tale of a Cat.—A cat was the cause of a great deal of trouble to the International Traction Company and the Niagara Falls Power Company a short time ago. According to New York *Electricity*, Puss climbed a trolley pole on the Buffalo and Lockport Electric Railway at Hoffman, a small hamlet west of Lockport, N.Y., and tried to walk on a feed wire. Her tail touched the parallel wire that carried the current back to Niagara Falls. There was a flash that could be seen for miles as the 24,000 volts of electricity passed through her body, which was burned to a crisp. Her lifeless body fell across both wires, and did not drop to the ground. This short-circuited the current, and caused a fuse at the Niagara Falls power house to burn out. The power was immediately cut off from all the lines running out of the power house. It was two hours before the cause of the trouble could be located, and the charred body of the cat removed from the wires. In the meantime power was shut off from a great part of Western New York, and hundreds of cars on electric railways were motionless.

The Engineering Trade.—The *Times* says that the rearrangement of the working agreement in the engineering trade which was made at a recent conference of the Federation of Employers and the Amalgamated Society of Engineers, held in London, is now being submitted to the operatives for approval. The agreement is that which was drawn up at the close of the great strike a few years ago. It has worked exceedingly well, especially the provisions for avoiding and settling disputes, and since it came into operation there have been scarcely any stoppages of work in the trade. The alterations made at the recent conference were in matters of detail only, and the agreement is still practically what it has always been. The conference was amicable in every way, and the revised agreement is almost certain to be accepted by the men. It has already been accepted on behalf of the employers. The fact that it has been so thoroughly successful is regarded by those interested as a very striking example of the value of conciliatory methods in trade disputes.

The Tramways and Light Railways Association.—This very strong body of firms and gentlemen interested in the extension and improvement of our means of communication, will have plenty of work to do in the coming Parliamentary Session. Mr. C. E. Brown recently resigned the post of secretary to take up a position under the Government in Ireland. His successor is Mr. Ernest Benedict, M.Inst.C.E., son of the late Sir Julius Benedict. Mr. Benedict has had a long and varied experience on railways and other engineering works both in this country and in India.

Electro-Harmonic Society.—To-night, at eight o'clock, the Electro-Harmonic Society holds one of its very popular Smoking Concerts at St. James's Hall Restaurant. The programme includes vocal music by Messrs. W. Mitton, F. Clive, and F. Hicks; humorous sketches by Mr. Percy French; humorous songs by Mr. George Schneider; violin solos by Mr. T. E. Gatehouse; and, what is always so acceptable at these concerts, an excellent selection of pieces is to be rendered by an orchestra. Mr. Izard will be at the piano.

Remember the Fifth.—The staff of the electricity works in a noted Scottish town treated themselves to a bonfire on the fifth of last month, and the local fire brigade, itching for occupation, treated themselves to the pleasure of putting it out, not without energetic opposition on the part of the electrical engineers. The fire-master and an ex-bailie were also well to the fore. The matter was investigated by the E.L. Committee, and this week it is announced that bonfires at the works will in future be barred.

Royal Institution.—The following are among the lecture arrangements at the Royal Institution before Easter:—Prof. J. A. Fleming, six lectures (adapted to young people) on "Waves and Ripples in Water, Air, and Æther."

Friday, January 17th. Lord Rayleigh. "Interference of Sound."

January 31st. Prof. A. Crum Brown, M.D., D.Sc, LL.D, F.R.S. "The Ions of Electrolysis."

February 21st. W. Duddell, Esq. "Musical and Talking Electric Arcs."

March 7th. Prof. H. Becquerel, D.C.L., Ph.D., Membre de l'Institut, Paris, Hon. Member R.I. "Radio-Active Bodies," (In French.)

Glasgow Exhibition.—The expenditure of £4,004 sanctioned for the illumination of the buildings and grounds has not been exceeded, £3,554 being the actual expenditure. The Glasgow Corporation have bought the arc lamp pillars used for ground lighting from the makers. They also bought some of the double-carbon arc lamps to replace some of the single-carbon lamps in the Springburn district, which latter the makers take back, allowing £5 each for them.

Society of Arts. — On Wednesday a paper on "Aluminium" was read by Prof. E. Wilson.

Electrical Engineer Volunteers.—A fifth detachment of Electrical Engineer Volunteers was provisionally enrolled on Friday last.

The Manchester Contract.—Many statements have been appearing in the London and Manchester papers to the effect that the accepted German tender for electrical machinery for the Manchester Corporation was £36,000 below that of any English firm. We believe, however, that this assertion is not correct, for Messrs. Dick, Kerr & Co.'s estimate for the same type of engines as quoted by the German company was only £12,000 higher.

London Locomotion.—A lecture with this title was delivered before the National Liberal Club on Tuesday night by Mr. J. Williams Benn, L.C.C. He urged that Parliament should insist upon the systematisation of the tube lines. He said that there were 1¼ billions of persons carried in London public conveyances every year.

Business Announcement.—Mr. Edward Brand, of Broad Street House, E.C., has taken the general agency for this country of Messrs. Meyer, Roth & Pastor's engineering works, of Cologne, Germany, who are makers of modern and practical automatic wire-working power presses and machinery for making all kinds of wire articles and small iron goods.

Bexley Tramways.—The U.D.C. have sealed the agreement appointing Messrs. Mordey & Dawbarn the Council's electrical engineers and advisers. Messrs. Mordey & Dawbarn had taken exception to one of the clauses of the agreement as being unfair to themselves, and at the last meeting of the Council, Mr. Mordey attended in person, and finally expressed his approval of the clause as amended, which ran: "That if the Council should put an end to the contract for any of the reasons mentioned, then the amount to be paid to Messrs. Mordey & Dawbarn for all services rendered to that date should be determined by arbitration under the Arbitration Act, 1889."

Appointments Vacant.—A chief traffic inspector is wanted for Cardiff Corporation Tramways; a chief assistant engineer for the Grimsby Electricity Department at £150; a shift engineer for Burnley Electricity Works at £120; a mains superintendent for Manchester at £150; an assistant engineer at £120, for Wakefield.

The English Electro-Metallurgical Company, Limited, v. the Glasdir Copper Mines, Limited.—In the Court of Appeal on Wednesday, before Lords Justices Vaughan-Williams, Romer and Cozens-Hardy, the above case was heard on appeal by the defendants from an order of Mr. Justice Joyce, who had granted an injunction restraining Mr. Nicholson, who had been appointed receiver in a debenture holder's action from using a patent, the license to work which had been granted to the company. Without calling upon counsel for the respondents, their Lordships decided that the license was not included in the security charged, and dismissed the appeal.

Personal.—Mr. A. W. Stewart, M.I.E.E., long associated with the Clydebank Engineering and Shipbuilding Company, Messrs. John Brown & Company, Limited, as manager of the electricity department, has resigned his position in order to start business on his own account as a consulting engineer. On the occasion of his leaving Clydebank he was presented with a non-magnetic gold watch by the officials and employés of the works. The successor to Mr. Stewart is Mr. Neilson, who acted as his assistant for several years.

Mr. H. G. Massingham has been appointed by the British Electric Traction Company, the new owners of the Exeter tramways, as their superintendent for that district.

Mr. John Addison has been appointed electrical manager to Messrs. Reunert & Lenz, engineers, Kimberley, South Africa. Mr. Addison was formerly with the Waverley Electric Company, Edinburgh.

Last Saturday the employés connected with the Southport Corporation Electric Tramways assembled at the Richmond Hotel to make a presentation of a spirit tantalus and silver cruet to Mr. R. J. Wilton, on his resigning the management of the tramways to take up the position of construction manager to Messrs. George Hill & Company, electric equipment manufacturers, Cornbrook, Manchester.

On Thursday last week a distinguished company of gentlemen interested in submarine telegraphy assembled at the Hotel Cecil at a complimentary dinner which was given to Sir John Denison Pender by the Eastern Telegraph Company and the Associated Telegraph Companies. Sir J. Wolfe-Barry presided, and among those present were the Marquis of Tweeddale, Mr. St. John Brodrick, Sir James Pender, and many others. The Chairman proposed the toast of the evening, and Sir J. Denison Pender replied in a speech covering briefly some of the events which had occurred during the 20 years of his connection with the submarine telegraphs as a director. Mr. Brodrick proposed "Submarine Cable Enterprise," and the Marquis of Tweeddale responded.

Lecture. — A lecture on "Electricity," illustrated by experiments, was recently delivered by Mr. George Johnson, M.Inst.C.E, before the members of the Bulawayo Scientific Association.

Re Shanghai Appointment.—We are asked to publish the following letter:—"I shall be glad if any of the gentlemen who were called to London to be interviewed for the above appointment, and have been refused payment of their travelling expenses, will kindly communicate with the undersigned, who, with three or four others, wish to take conjoint action for the recovery of these expenses.—Jas. Moss, M.I.E.E, Tower Chambers, Brown Street, Manchester."

Commercial Development Corporation, Limited, v. Atkins & Applegarth.—In the Chancery Division of the High Court of Justice on Friday, December 6th, a motion in this case came before Mr. Justice Buckley.—Mr. Astbury, K.C., on behalf of the plaintiffs, moved for an injunction to restrain the defendants, their solicitors or agents, from giving any notice, or taking any steps, to withdraw a notice of appeal given in connection with an action, in which Atkins & App'egarth were plaintiffs, from abandoning or withdrawing the appeal, or from applying to have the appeal struck out of the list.—After brief arguments of counsel, Mr. Justice Buckley expressed the opinion that an action could not be said to have been brought to a final judgment when notice of appeal had been served, and the appeal remained undisposed of. Atkins & Applegarth had, therefore, not fulfilled their obligations under the 1898 agreement, and accordingly he granted the injunction asked for, the costs of the motion to be made costs in the action.

In the Court of Appeal, on Wednesday, before Lords Justices Vaughan-Williams, Romer and Cozens-Hardy, Mr. Bousfield, K.C., mentioned this case, which was down for hearing on an application by the defendant company to strike out the appeal from the list. It was stated that there would be an appeal from the decision of Mr. Justice Buckley, who had the matter before him recently, and under these circumstances their Lordships thought it better that both appeals should come on together, and directed accordingly.

THE CENTRAL STATION ENGINEER.

The following appointments have been made by the Council to the staff at the Bootle electricity works:—Mr. W. H. Hall, chief indoor assistant; Mr. J. B. Hudson, chief outdoor assistant. Mr. T. Dawson Clothier is the borough electrical engineer.

Mr. F. Fernie, of Brighton, has been appointed assistant electrical engineer at Worthing Electricity Works.

Mr. Minshall, the borough electrical engineer of Croydon, has resigned his position. The E.L. Committee expressed deep regret at losing his services.

Mr. R. Hammond has appointed Mr. E. A. Ellicot, chief assistant engineer on the distributing staff of the London Electric Supply Corporation, to be clerk of works over the laying of the mains in Dublin.

We understand that the Corporation electric tramways engineer of Southend has resigned his position.

The Dewsbury Corporation have made a grant of £50 to Mr. Albert Pickersgill, assistant electrical engineer, in consideration of the extra duties which devolved upon him during the vacancy in the office of borough electrical engineer.

Mr. Neville Walton, of Weston-super-Mare, has been appointed third assistant electrical engineer at the King's Lynn Corporation electricity works.

Mr. Leonard Breach has been appointed assistant engineer in the testing department at the Bolton Corporation's electricity works.

The Bradford Corporation has advanced the salary of Mr. William Jones, chief engineering assistant at the electricity works, from £225 to £275 per annum; and has appointed Mr. Charles R. Brown, of Messrs. J. H. Holmes & Co., chief assistant to the superintendent engineer, at £150.

The salary of the Walsall electrical engineer, Mr. A. Wylie, was on Monday increased by the Town Council from £300 to £400 per year as from November 1st. Further increases of £50 are to be made in the next two years, when the maximum of £500 will have been reached.

THE INSTITUTION OF ELECTRICAL ENGINEERS' DINNER.

The annual dinner of the Institution was held at the Hotal Cecil last Monday evening, Mr. W. E. Langdon presiding. Among the company present, which numbered over 300, were Sir F. Mowatt, K.C.B.; Sir W. J. L. Wharton, K.C.B.; the Hon. Sir D. Tennant, K.C.M.G. (Agent-General for Cape Colony); Gen. Sir R. Harrison, Sir J. Crichton Browne, F.R.S., Sir J. D. Pender, K.C.M.G., Mr. J. W. Swan, F.R.S., Mr. J. S. Forbes, Major-Gen. Salmond and Archdeacon Sinclair.

After the loyal toasts had been honoured, Sir J. Crichton Browne gave "The Imperial Forces." Among these he reckoned electricity as a very important line of defence in warfare.

In responding for the Navy, Admiral Wharton referred to the applications of electricity to the driving of the auxiliary machinery on board ship and to the improvements in dynamos, particularly as regards the absence of external magnetism. This had enabled the authorities to reduce the permissible distance between dynamos and compasses from 50 to 25 ft., and he looked forward to the time when these two would, like the proverbial lion and lamb, lie down together in peace.

General Sir R. Harrison, Inspector-General of Fortifications, which owing to our excellent Navy we are supposed not to need, replied for the Army, and in doing so paid a tribute to the work of the E.E.R.E.V. He also referred to the usefulness of electricity for searchlight purposes. "They are better lights than these," he remarked, referring to the pumping of the arcs in the dining hall.

Colonel Crompton, for the Auxiliary Forces, reminded his hearers that there were at present in South Africa 170 electrical engineers, doing excellent service at the front. Sixty more were on the way, and 100 more still were ready to follow them. The E.E. Volunteers had established a record, for they had sustained the fewest casualties of any corps, and had had the lowest percentage disabled through sickness. This the gallant Colonel attributed to discipline and obedience to orders in the matter of refusing to drink water from questionable sources.

The toast of "Engineering and Science" was proposed by Prof. S. P. Thompson, who said the progress of science and of engineering went hand in hand; the one was a sort of twin sister to the other, and they were interdependent. He referred again to the fact that the tube railway system that had made, and was making, such rapid headway in London and elsewhere, was not a foreign importation, but was a result of the work of the late Mr. Greathead, whose tubes had been in use for the past 10 years.

Mr. C. Hawksley, President Inst.C.E., replying for engineering, instanced the great advances in road making, in canals, and waterways. In touching on the improvements in steam engines since the days of Watt, he remarked that the coal consumption had been reduced to one-fifth of what it was at the beginning of the century. Gas was not done for yet, and when its lighting days are over, it will provide a cheap fuel for the driving of electric machinery.

Mr. R. T. Glazebrook, replying for science, reminded us of the pioneer work of Faraday and Maxwell, and, as usual, put forward the claims of the National Physical Laboratory.

The toast of "The Institution of Electrical Engineers" was given by Sir David Tennant, and responded to by the President. Referring to the nomadic existence of the Institution, Mr. Langdon said that whilst it had so many local sections to subsidise, and other channels for its funds, it was not possible to put much on one side towards a home of its own. He was of opinion that there would be great advantages in the centralisation of the learned societies, and looked forward to the time when they would all meet in one huge building and under one roof. The Prince of Wales had told the old country to "wake up" if she wished to hold her own in the markets of the world, and the President, in concluding, advocated the appointment of a Minister for Commerce and Manufacture, which he considered equally as important as the office of Minister of Agriculture.

The toast of "Our Guests," proposed by Major-General Webber, in what he jocularly remarked would have been the speech of the evening had it not been so late, was responded to by Sir F. Mowatt and Mr. J. Balfour Browne, K.C. In olden times, said the latter speaker, it was customary, on a change of dynasty, for the courtiers to greet the incoming dynasty. The dynasty of the future was that of electrical engineering, and he was among those who extended to it a very cordial greeting. The steam locomotive was effete, and in future, instead of an engine of 100 tons hauling a train no heavier than itself, there would be stay-at-home generators sending their currents along the lines to feed self-propelling coaches. England had been told to wake up, and she would have to wake up to the fact that legislation is a serious clog on the wheels of progress. Many of the large power distribution schemes now awaiting Parliamentary sanction had been rendered ricketty from birth owing to legislation in favour of the vested interests of municipalities. Many a light railway scheme had been crippled owing to the supposed vested interests of the great railway systems. But the railways have no such vested interests as they suppose, and it will be well for them to recognise this before it is too late.

The proceedings were then brought to a close, after a thoroughly enjoyable evening had been spent.

CITY NOTES.

India-Rubber, Gutta-Percha and Telegraph Works Company.

The directors' report for the year ended September 30th, 1901, to be presented at the meeting on Tuesday, December 7th, reads:—

The accounts show, after provision for doubtful debts, a net profit for the past 12 months of £56,057 1s. 5d. Adding £48,750 6s. 10d. brought forward, and deducting £12,500 interim dividend paid in June, there remains a disposable balance of £92,307 8s. 3d. The directors recommend the distribution of a dividend of 15s. a share, free of income-tax, amounting to £37,500, making, with the interim dividend paid in June, a total payment of 10 per cent. for the year, and leaving £54,807 8s. 3d. to be carried forward. The general business shows a slight falling off when compared with last year. The cost of raw material, which had been high at the beginning of the year, became lower at its close. The cable steamer *Silvertown* completed the laying of the Waterville (in Ireland) and Weston-super-Mare cable, the manufacture and shipment of which was mentioned in the last report. The *Buccaneer* has also been employed. Since the closing of the financial year the *Dacia* has been employed by the Spanish Government and by the Western Telegraph Company, and after her return to London will carry to Brazil and lay a cable which has just been manufactured. The works at Silvertown and Persan have been maintained in their usual state of efficiency, novel machinery being introduced at the former, and land for the extension of the latter having been acquired. Mr. S. Wm. Silver and Mr. Matthew Gray, having resigned their seats on the board, have been appointed extraordinary directors of the company. The vacancies thus created have been filled by the appointment of Mr. George Henderson and Mr. Charles H. Moore. The directors regret to report the death of Mr. James McKinlay, who, with great advantage to the company, occupied the position of cashier and buyer at the company's Silvertown Works for the last 34 years. Mr. Abraham Scott and Mr. George Henderson, the retiring directors, offer themselves for re-election.

Prospectus.—Messrs. Royce, Limited, electrical manufacturers, of Manchester, have been inviting subscriptions for 30,000 6 per cent. cumulative preference shares, the additional capital being required for extension of the business.

Eastern Extension, Australasia and China Telegraph Company.—The Hon. Arthur Grenville Brodrick has been elected a director to fill the vacancy caused by the death of Mr. Clement Sneyd Colvin, C.S.I.

TRAFFIC RECEIPTS.

Blackburn Corporation Tramways.—The receipts for the week ending Dec. 6th were £461; corresponding week last year, £416; increase, £45. Total to date, £24,643; corresponding period last year, £21,864, increase, £2,779 Miles of track open, 8½.

Blackpool and Fleetwood Tramways.—The receipts for the week ending December 7th were £158; corresponding week last year, £140; increase, £18. Total receipts to date, £20,514; corresponding period last year, £19,852; increase, £662.

Bristol Tramways and Carriage Company.—The receipts for the week ending December 7th were £3,816; corresponding period last year, £3,066; increase, £750.

British Electric Traction Company.—The following returns are issued of the undertakings of this company for the week ending November 29th :—

Company.	Amount £	Comparison with corresponding week of last year. + £	Comparison with corresponding week of last year. — £	No. of weeks.	Aggregate. Amount. £	Aggregate. Inc. or Dec. + £	Aggregate. Inc. or Dec. — £
Croydon*	439	200	—	48	15,915	1,757	—
Devonport	357	—	—	23	9,107	—	—
Dudley—Stourbridge	596	104	—	48	31,576	15,909	—
Gateshead	579	—	—	29½	17,370	—	—
Greenock-Pt. Glasgow	391	—	—	8	2,109	—	—
Hartlepool	170	—	13	48	10,858	1,301	—
Kidderminster ..	83	—	2	48	5,841	682	—
Merthyr	201	—	—	34	8,557	—	—
Oldham—Ashton ..	450	—	1	48	23,896	3,165	—
Poole	176	—	—	24	9,717	—	—
Potteries	1,353	193	—	48	67,110	19,356	—
Southport†	111	—	21	48	7,894	—	2,788
South Staffordshire‡	689	—	1	48	37,109	2,399	—
Swansea	388	—	2	48	21,096	4,256	—
Taunton	49	—	—	14½	1,165	—	—
Tynemouth	165	—	—	36	10,072	—	—
Wolverhampton Dist.	71	22	—	48	3,157	732	—

* Partly horse † Reconstructing. ‡ Partly steam.

Central London Railway.—The receipts for the week ending Dec. 7th were £6,957; corresponding week last year, £5,740; increase, £1,217. Total receipts from July 1st (23 weeks), £141,252. Miles open, 6.

City and South London Railway.—The receipts for the week ending Dec. 8th were £2,931; corresponding week last year, £1,915; increase, £1,016. Total from July 1st to date, £48,867; corresponding period last year, £37,776; increase, £11,091. Miles open, 6¼; corresponding period last year, 4¾.

Dublin United Tramways Company.—The receipts for the week ending December 6th were as follows:—D.U.T. Co., electric cars, £3,331 6s. 1d.; D.S.D. Co., electric cars, £686 6s. 4d.; total, £4,017 12s. 5d.; corresponding period last year—D.U.T. Co., electric cars, £3,328 3s. 4d.; ditto, horse cars, £23 2s. 8d.; D.S.D. Co., electric cars, £691 0s. 6d.; total, £4,042 6s. 6d.; decrease, £24 14s. 1d.; aggregate to date, £107,636 11s. 10d.; aggregate to date last year, £106,511 15s. 7d.; increase, £1,124 16s. 3d. The mileage worked is 45 miles electrically, as against 43 miles electrically, and two miles by horses, for the corresponding period last year.

Dover Corporation Tramways.—Total to date, £8,629 4s. 7½d.; corresponding period last year, £8,218 10s. 9d.; increase, £410 13s. 10½d. Miles of track open, 3. Number of cars, 1901, 12; 1900, 11.

Glasgow Corporation Trams.—For the week ending December 7th, 1901, £10,973 11s. 6d., compared with £9,027 7s. 6d. for corresponding week last year. Since June 1st, 1901, total, £338,301 15s. 11d., against £255,222 13s. 2d; increase, £83,079 2s. 9d.

Liverpool Overhead Railway.—The receipts for the week ending Dec. 8th were £1,417; corresponding week last year, £1,488; decrease, £71. Total from July 1st to date, £36,403; corresponding period last year, £38,131; decrease £1,728. Miles open, 6 miles 57 chains.

STOCKS AND SHARES.

Wednesday Evening.

The money market gives no particular cause for uneasiness to the Stock Exchange, and the penultimate account of the year was arranged with ease. Business is shy of returning to the markets, considered as a whole, but the electricity supply division is exceptionally active, although quotations display little variation. Of course, the main excitement this week is centred round the electrical traction proposals now being submitted by the dozen, while the settlement of the Underground Companies' dispute is responsible for a lively fillip in the stocks and shares connected with the electrification of the "sewer" lines.

The leakage of the secret concerning the Board of Trade's decision in favour of Mr. Yerkes' system, is certainly to be deprecated, and it seems unfair that the Stock Exchange should have received the news al least six hours before even the rumour spread to the public. A telegram came into the market with the news on Monday, announcing that the decision was all in favour of the District. Forthwith the two Underground stocks rapidly advanced, Metropolitan, somewhat singularly, scoring much the larger rise with a jump of 5 per cent. District stock followed more leisurely, but those who took the hint thrown out in this column last week can already secure a good profit, which we should advise them not to be in a hurry to take at present.

The Board of Trade's rumoured announcement was made the signal for the marketing of Metropolitan District electric traction shares, which were mentioned by us some time ago, and the price is supposed to be about 2½ premium. British Westinghouse Preference are harder at 5⅜, and it may be of interest to remark that some 7,000 shares have changed hands during the last fortnight. Westinghouse Ordinary shares are creeping into the newspapers, and the price is called at 5 to 5½ for the £10 fully paid shares. The company having secured a good slice of contracts over the Underground electrification, it seemed well to some of the insiders to start a market in the Ordinary shares; but we confess the tactics adopted for securing publicity to the fact are not wholly commendable. When one member of the Stock Exchange does a single bargain with another member in order that the fact may be noted in a number of daily journals, it is advisable to beware of rushing madly into those shares.

The stocks of Electrical Railways proper are maintaining thei firm attitude, and further buying of City and South London upon the Cattle Show traffic expectations has helped this quotation to 65. Central London varieties showed some inclination to tone off upon the publication of a fresh scheme to be brought forward by the London United Tramways Company, but the stocks hardened again. The scheme referred to is, briefly, a suggestion for a new and competing tube railway from Hammersmith to Charing Cross, with feeders westward. The company is to be styled the London United Electric Railways, Limited, and should it come into active operation, the Central London will no doubt regret that it allowed its powerful ally to unloose the earlier hand of friendship.

Mersey Ordinary shares are £1, unchanged at the prospect of electrification (which we presume would also spell reconstruction), and Tilbury continues at 138. Metropolitan Consolidated is 77, District, 29½, and Great Northern and City Preferred "A" share are 8½.

No market exists for the newly-issued Isle of Thanet Electric Railway and Lighting shares. The prospectus is far from attractive, chiefly on account of the earnings being worked out on the receipts for spring and summer months, when, naturally, the takings would be large. Winter prospects, the prospectus discreetly omits to mention. As regards other new emissions, the London United Tramways Preference are ⅞ premium for Special Settlement and ⅛ less for cash, the Debentures keeping at 2 over par. The earlier 4 per cent. Debenture stock is 105. Anglo-Argentine Trams have eased off slightly to 3¾ in sentimental sympathy with Argentine Government stocks, now depressed by reason of the threatened hostilities between the Silver Republic and Chili. British Electric Traction shares are very steady, and the Ordinary in particular command a fairly active market. Calcutta Tramways maintain their last week's rise at 12½, and the Debenture stock is changing hands at 107. Dublin Trams are 12; so are Belfast. Blackpool and Fleetwood at 13½ and Cape Electrics at 2 are barely mentioned, and Potteries Electric Traction remain at 11½, the Preference being 10.

Charing Cross Electric Ordinary are very dull upon the new issue of shares, which seems likely to achieve fiasco unless it was well underwritten. For the directors to issue Ordinary shares at 7½, the shares to carry no dividend for 20 months, was to court failure. As one Stock Exchange jobber put it, "It is like offering £100 stock at 150, and people will not pay such a price if they are to get no dividend for a year and a half. Anything might happen in that time." A new issue of Westminster Preference is to be made very shortly, which probably explains some of the recent dulness exhibited by the present Ordinary. City of London are again neglected but the Preference have picked up this week and are ½ better. Chelseas are much the best market, and good buying is in progres for the time being.

The telegraph department is rather erratic, the Anglo-American Company stocks showing weakness upon the completion of the fourth cable by the Commercial Cable Company, while Eastern Ordinary is better at the addition of the Right Hon. W. L. Jackson, M.P. to the board. Eastern Extensions have improved in sympathy. West Coast of America have shed 2s. 6d. National Telephones are very dull, the storm of hostility to the "Competitive Amalgamation," in which even *Punch* has joined, rendering the market timid. We may observe that strenuous efforts are being made by the company to obtain an extension of its license after 1911, but in face of the nation's present temper, the Government are hardly likely to grant the petition. It is understood that the lately-offered Preferre shares were very coldly received by the public, the underwriters getting left with about 90 per cent.

SHARE LIST OF ELECTRICAL COMPANIES.—TELEGRAPH AND TELEPHONE COMPANIES.

Present Issue.	NAME.	Stock or Share. †	Dividends for the last three years. 1898.	1899.	1900.	Closing Quotations Dec. 4th.	Closing Quotation Dec. 11th.	Business done during week ended Dec. 11th. 1901. Highest.	Lowest
82,300	African Direct Telegraph, 4 % Debs.	100	...	...	...	99 —102	99 —102	...	...
25,000	Amazon Telegraph Co.'s shares, Nos. 1 to 25,000	10	...	...	...	3½— 4½	3½— 4½	...	...
119,700£	Amazon Telegraph 5 % Debs., Nos. 1 to 1,250 Red. ...	100	...	...	...	78 — 83	78 — 83	...	...
804,720	Anglo-American Telegraph	Stock	£3 9s.	73/6	3½%	52 — 55	52 — 55	...	...
3,097,640	Do. do. 6 % Pref.	Stock	6 %	6 %	6 %	98 —100	98 —100	99	98
3,097,640	Do. do. Deferred	Stock	18s. %	£1 7s.	5s. %	9½— 9¾	9 — 9½	9½	9 3/16
44,000	Chili Telephone, Nos. 1 to 44,000	5	3 %	4 %	5 %	3½— 4	3½— 4	3¾	...
13,333,300$	Commercial Cable	$100	8 %	8 %	...	180 —190	180 —190	...	...
1,741,029£	Do. do. Sterling 500 year 4 % Deb. Stock Red.	Stock	...	...	...	101 —103	101 —103	101⅜	...
16,000	Cuba Telegraph	10	8 %	7 %	...	5 — 6	5 — 6	5½	...
6,000	Do. 10 % Pref.	10	10 %	...	...	13½— 14½	13½— 14½	...	...
12,931	Direct Spanish Telegraph	5	4 %	4 %	4 %	3 — 4	3 — 4	...	...
6,000	Do. do. 10 % Cum. Pref.	5	...	...	...	8½— 9½	8½— 9½	...	...
30,000£	Do. do. 4½ % Debs.	50	...	...	...	100 —104 %	100 —104 %	...	...
60,710£	Direct United States Cable	20	3½%	3½%	3½%	10⅜— 11¼	10⅜— 11¼	11 3/16	10⅜
104,300£	Direct West India Cable, 4½ % Reg. Deb.	100	...	...	...	100 —103	100 —103	...	...
4,000,000	Eastern Telegraph, Ord. Stock	Stock	7 %	7 %	7 %	138 —142	140 —144	143	138½
1,930,607	Do. 3½ % Pref. Stock	100	...	...	...	92 — 95	92 — 95	93⅜	92¼
1,432,268£	Do. 4 % Mort. Deb. Stock Red.	Stock	...	...	...	112 —115	112 —115	...	...
300,000	Eastern Extension, Australasia, and China Telegraph ...	10	7 %	7 %	7 %	13¾— 14¼	14 — 14½	14⅜	14 1/16
320,000£	Do. 4 % Deb. Stock	Stock	...	...	...	113 —118	113 —118	...	...
300,000£	Eastern and South African Telegraph, 4 % Mort. Deb. Nos. 1 to 3,000, red. 1909	100	...	5½%	...	100 —103	100 —103	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1—8,000	25	...	...	...	100 —103	100 —103	100	...
180,227	Globe Telegraph and Trust	10	5⅛%	5½%	5½%	11½— 11⅝	11½— 11⅝	11½	11⅛
180,042	Do. do. 6 % Pref.	10	6 %	...	...	14⅜— 15½	14⅜— 15½	15	14 15/16
150,000	Great Northern Telegraph, of Copenhagen	10	12½%	...	15 %	30 — 32	30 — 32	31½	...
78,000£	Halifax and Bermuda Cable, 4½ % 1st Mort. Debs., within Nos. 1 to 1,200, Red.	100	...	...	...	100 —103	100 —103	...	...
17,000	Indo-European Telegraph	25	10 %	10 %	10 %	40 — 44	40 — 44	42	41½
100,000£	London Platino-Brasilian Telegraph, 6 % Debs.	100	...	...	...	102 —105	102 —105	...	...
72,680	Montevideo Telephone, Limited, Ord., Nos. 1 to 72,680 ...	1	...	2½%	...	¼— ½ xd	¼— ½	...	...
86,492	Do. do. do. 5 % Pref., Nos. 1 to 86,492	1	4 %	5 %	...	¾— 1 xd	¾— 1	...	...
590,000	National Telephone, 1 to 590,000	5	6 %	5 %	5 %	3⅝— 4	3⅜— 3⅝	4	3 11/16
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	12 — 14	12 — 14	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	12 — 14	12 — 14	...	...
250,000	Do. 5 % Non-cum. 3rd Pref., 1 to 250,000	5	5 %	5 %	5 %	4¾— 5	4¾— 5	4⅞	4¾
2,000,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	95 — 98	95 — 98	...	...
500,000£	Do. 4 % Deb. Stock Red.	100	...	...	4 %	99 —102	100 — 103	101	...
171,504	Oriental Telephone and Elec., Nos. 1 to 171,504, fully paid	1	5 %	5 %	6 %	5/16— 1 1/16	1/16— 1 1/16	...	...
100,000£	Pacific and European Tel., 4 % Guar. Debs., 1 to 1,000 ...	100	...	...	...	100 —103	100 —103	100¼	...
11,839	Reuter's	8	5 %	5 %	5 %	7 — 8	7 — 8	7 1/16	7
3,303	Submarine Cables Trust	Cert.	...	...	...	125 —130	125 —130	125½	125
58,000	United River Plate Telephone	5	6 %	7 %	...	5 — 5½	5 — 5½	5 3/16	5
40,006	Do. do. 5 % Cum. pref. Nos. 1—40,000	5	...	...	...	4⅜— 5¼	4⅜— 5¼	...	...
179,947£	Do. do. 5 % Debs.	Stock	...	...	...	104 —107	104 —107	...	...
155,600	West African Telegraph, 5 % Debs....	100	...	...	...	99 —102	99 —102	...	...
30,008	West Coast of America, Nos. 1—30,000 and 53,001—53,008	2½	...	...	...	⅛— ⅜	⅛— ⅜	...	...
150,000£	Do. do. 4 % Debs., 1—1,500 gua. by Braz. Sub. Tel.	100	...	...	...	100 —103	100 —103	...	...
207,930	Western Telegraph, Ltd., Nos. 1—207,930	10	7 %	7 %	7 %	14¼— 14¾	14¼— 14¾	14 7/16	14¼
75,000£	Do do. 5 % Debs. 2nd series, 1906 ...	100	...	...	...	104 —107	104 —107	...	...
348,777£	Do. do. 4 % Deb. Stock Red.	100	...	...	...	103 —106	103 —106	...	...
88,321	West India and Panama Telegraph	10	2 %	5%	...	⅜— ⅝	⅜— ⅝	...	...
34,563	Do. do. do. 6 % Cum. 1st Pref. ...	10	...	...	...	5 — 6 xd	5 — 6 xd	...	...
4,669	Do. do. do. 6 % Cum. 2nd Pref. ...	10	...	...	...	3½— 4½	3½— 4½	...	...
80,000£	Do. do. do. 5 % Debs., Nos. 1 to 1,800	100	...	...	...	101 —104	101 —104	103	...

ELECTRICITY SUPPLY COMPANIES.

100,000	Blackheath and Greenwich Dist. Electric Light, Ord. ...	1	...	...	...	⅜— ⅝	⅜— ⅝	...	...
100,000	Do. 4½% 1st Deb. Stock, Prov. Certs.	100	...	...	...	97 — 102	97 —102	...	...
19,661	Brompton & Kensington Elec. Lt. Sup., Ord., 101 to 19,761	5	6 %	6 %	6 %	8¼— 8¾	8¼— 8¾	8 9/16	...
20,000	Do. do. 7 % Cum. Pref....	5	...	...	...	8¼— 8¾	8¼— 8¾	...	...
50,000	Charing Cross and Strand Electricity Supply	5	8 %	9 %	9 %	8¼— 9½	7½— 8½	8⅝	7⅝
50,000	Do. do. do. do. 4½% Cum. Pref.	5	...	...	...	5¼— 5⅝	5¼— 5⅝	5⅝	...
250,000	Do. do. do. do. 4% Deb. Stock Red.	100	...	...	...	105 —107	105 —107	105½	...
34,000	*Chelsea Electricity Supply, Ord.	5	6 %	6 %	5½%	5¼— 5⅜	5⅜— 6¼	6	5⅜
150,000£	Do. do. do. % Deb. Stock Red. ...	Stock	...	...	...	109 —112	109 —112	...	...
70,579	City of London Electric Lighting, Ord. 40,001—110,579...	10	6 %	4 %	0 %	9 — 10	9 — 10	9⅝	...
40,000	Do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	11½— 12½	12 — 13	12¾	12½
400,000£	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	...	...	...	122 —127	122 —127	...	...
200,000	Do. 4½% 2nd Deb. Stock, Prov. Certs., all paid	100	...	...	...	102 —105	102 —105	...	...
40,000	County of Lond. & Brush Prov. Elec. Ltg., Ord. 1—40,000	10	nil	4 %	4 %	8½— 9½	8½— 9½	8 13/16	...
20,000	Do. do. do. 6 % Pref., 40,001—60,000	10	6 %	6 %	6 %	12 — 13	12 — 13	12	11¾
400,000£	Do. 4½ % Deb. Stock, Prov. Certs (all paid) Rd. ...	...	...	...	...	105 —108	105 —108	105½	...
35,500	Edmundson's Elec. Corp., Ord. Shares	5	6 %	6 %	7 %	5½— 6	5½— 6	5 13/16	...
20,000	Do. do. 6 % Cum. Pref.	...	...	...	...	5½— 6	5½— 6	5 15/16	...
120,000£	Do. do. 4½ % 1st Mort. Deb. Stock. ...	100	...	...	...	105 —108	105 —108	107	...
21,000	Kensington and Knightsbridge Electric, Ord.	5	...	...	...	11 — 12	11 — 12	...	...
90,000	Do. do. do. 4 % Deb. Stock	Stock	...	...	...	101 —104	101 —104	...	...
110,000	London Electric Supply Corporation, Limited, Ord. ...	3	...	...	...	1½— 1⅝	1½— 1⅝	...	...
49,840	Do. do. do. do. 6 % Pref.	5	6 %	...	...	3½— 4½	3½— 4½	3⅞	...
250,000£	Do. do. do. 4% 1st Mt. Db. Stock Rd.	Stock	...	...	...	96 —100	96 —100	...	...
98,769	Metropolitan Electric Supply, 101 to 62,500	10	5 %	5 %	6 %	13½— 14½	13½— 14½	14 3/16	14 1/16
220,000£	Do. 4½% First Mortgage Debenture Stock	...	...	...	...	113 —116	113 —116	112	...
250,000£	Do. 3½% Mort. Deb. Stock Red.	Stock	...	...	...	96 — 99	96 — 99	98	97
8,652	Notting Hill Electric Lighting	10	6 %	7 %	7 %	15 — 16	15 — 16	15½	...
40,000	St. James's and Pall Mall Electric Light, Ord.	5	14½%	14½%	14½%	15½— 16½	15½— 16½	15⅝	15½
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8 — 9	8 — 9	8¾	8 1/16
150,000£	Do. do. 3½ % Deb. Stock Red. ...	100	...	...	...	97 —100	98 —101	...	...
12,000	Smithfield Market Elect. Supply, Ord.	5	...	...	...	2 — 2½	2 — 2½	...	...
50,000£	Do. do. 4 % Deb.	100	...	...	...	80 — 90	80 — 90	...	...
65,000	South London Electricity Supply, Ord.	5	...	...	...	2 — 2½	2 — 2½	...	...
109,518	Westminster Electric Supply, Ord.	5	12 %	13 %	10½%	11½— 12½	11½— 12½	12¼	11¾

* Subject to Founders Shares.
† Quotations on Liverpool Stock Exchange.
‡ Unless otherwise stated all shares are fully paid.
§ Dividends paid in deferred share warrants, profits being used as capital.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES.—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL COMPANIES.

Present Issue.	NAME.	Stock or Share.	Dividends for the last three years.			Closing Quotation Dec. 4th.	Closing Quotation Dec. 11th.	Business done week ended Dec. 11th, 1901.	
		‡	1898.	1899.	1900.			Highest	Lowest.
20,000	British Aluminium 7 % Cum. Pref.	10	...	...	...	4½ — 5½	4½ — 5½	...	...
300,000*l*	Do. do. 5 % 1st Mort. Deb. Stock Red. ...	Stock	...	...	...	87 — 91	87 — 91	...	...
62,074	British Electric Traction	10	6 %	8 %	9 %	14 — 14¼	14 — 14¼	14⅜	14⅛
90,000	Do. do. 6 % Cum. Pref.	10	...	...	...	11¾ — 12¼	12 — 12½	12¼	12⅛
600,000*l*	Do. do. 5 % Perpetual Debenture Stock ...	Stock	...	...	...	122 —125	122 —125	123½	...
70,000	British Insulated Wire Ord.	5	15 %	20 %	15 %	8 — 9	8 — 9	...	...
70,000	Do. do. 6 % Cum. Pref.	5	...	...	...	5½ — 5¾	5½ — 5¾	...	...
50,000	¶Browett, Lindley & Co. (1899), Ord.	£1	...	...	8 %	⅞ — 1	⅞ — 1	...	...
50,000	¶ „ „ „ 6 % Cum. Pref.	£1	...	...	6 %	1⅛ — 1 1/16	1⅛ — 1 1/16xd	1 7/16	...
105,731	Brush Elecl. Enging., Ord., 1 to 105,731	2	4 %	5½ %	5 %	1⅜ — 1⅝	1⅜ — 1⅝	...	...
150,000	Do. do. Non-cum. 6 % Pref.	2	6 %	6 %	6 %	1⅞ — 2⅛	1⅞ — 2⅛	2⅛	...
125,000*l*	Do. do. 4½ % Perp. Deb. Stock	Stock	...	...	...	102 —105	102 —105	104½	103½
125,000*l*	Do. do. 4½ % Perp. 2nd Deb. Stock ...	Stock	...	...	...	99 —102	99 —102	...	...
30,000	Callender's Cable Construction shares, Nos. 1—30,000 ...	5	15 %	15 %	15 %	14½ — 15½	15½ — 16½	16¼	15¼
40,000	Do. do. 5 % Cum. Pref.	5	...	...	...	5¾ — 6	5¾ — 6¼	5⅞	...
90,000*l*	Do. do. 4½ % 1st Mort. Deb. Stock Red ...	Stock	...	...	...	112 —116	112 —116	108	...
1,969,800	Central London Railway, Ord. Stock	Stock	...	...	...	107 —110	107 —110	109	107
440,100	Do. do. 4 % Pref. Stock	Stock	...	...	...	105 —108	105 —108	107½	...
440,100	Do. do. Def. do.	Stock	...	...	...	107 —110	107 —110	107	...
855,000	City and South London Railway	Stock	2⅛%	1⅞%	1¼%	63 — 65	64 — 66	66	64
47,500	Do. do. Ord. shares Nos. 22,501 to 70,000 ...	10	...	...	...	6 — 6½	6 — 6½	6½	6¼
54,000	Crompton & Co., Nos. 1 to 54,000	3	6 %	7½%	8 %	3 — 3½	3 — 3½	3⅝	...
100,000*l*	Do. 5 % 1st Mort. Reg. Debs., 1 to 900 of £100, and 901 to 11,000 of £50 red	...	...	...	...	100 —105	100 —105	...	...
99,261	Edison & Swan Utd. El. Lgt., "A" shares, £3 pd. 1 to 99,261	5	6 %	6 %	2½%	⅛ — ⅜	⅛ — ⅜	...	...
17,139	Do. do. do. "A" Shares, 01—017,139 ...	5	6 %	6 %	2½%	1½ — 2½	1½ — 2½	...	...
344,023*l*	Do. do. do. 4 % Deb. Stock Red ...	100	...	...	...	80 — 85	80 — 85	...	...
100,000*l*	Do. do. 5% 2nd Deb. Stock Prov. Certs. all pd.	100	...	...	...	84 — 89	84 — 89	...	...
112,100	Electric Construction, 1 to 112,100	2	6 %	6 %	6 %	1⅜ — 2¼	1⅜ — 2¼	...	...
31,390	Do. do. 7 % Cum. Pref., 1 to 31,390... ...	2	7 %	...	...	2½ — 3	2½ — 3	2 1/16	...
182,500*l*	Do. do. 4 % Perp. 1st Mort. Deb. Stock ...	Stock	...	...	...	98 —102	98 —102	...	...
18,000	General Elec. Co. (1900) 5 % Cum. Pref.	10	...	...	...	10 — 10½	10 — 10½	...	...
150,000	Do. do. 4 % Mort. Deb.	Stock	...	...	...	99 — 102	99 —102	...	...
35,000	Henley's (W. T.) Telegraph Works, Ord.	5	14 %	15 %	20 %	16 — 17	16½ — 17½	16¾	...
35,000	Do. do. do. 4½ % Pref.	5	...	4½%	4½%	5½ — 6	5½ — 6	...	...
50,000*l*	Do. do. do. 4½ Mort. Deb. Stock...	Stock	...	...	...	112 —116	112 —116	...	...
50,000	India-Rubber, Gutta-Percha and Telegraph Works ...	10	10 %	10 %	...	23 — 24	23 — 24	23⅜	23 3/16
300,000*l*	Do. do. do. 4 % 1st Mort. Deb ...	100	...	...	...	100 —103	100 —103	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	3¼%	3¾%	3¼%	5⅞ — 6⅛	5⅞ — 6⅛	...	...
10,000	† Do. do. Pref., £10 paid	10	5 %	5	...	12 — 12½	12 — 12½	...	...
7,500	Parker (Thomas), Limited, Ord., Nos. 1 to 7,500 ...	10	...	...	...	15½—16½	15½ — 16½	...	...
	§Rosling, Appleby & Fynn 6 % Cum. Pref.	£1	...	...	6 %	19/- to 20/-	... — ...	...	...
37,350	Telegraph Construction and Maintenance	12	15 %	15 %	17½%	38 — 42	38 — 42	...	...
150,000*l*	Do. 4 % Deb. Bds. Nos. 1 to 1,500 Red. 1909 ...	100	...	...	...	104 —106	104 —106	...	...
25,000	Telegraph Manufacturing, Ord. Nos. 1 to 25,000	5	8 %	12 %	12 %	10½ — 11½xd	10½ — 11½	...	...
20,000	Do. do. 5 % Cm. Prf. Nos. 1 to 20,000...	5	...	...	...	5½ — 6	5½ — 6	...	...
540,000*l*	Waterloo and City Railway, Ord. Stock	100	3 %	3 %	3 %	91 — 94	91 — 94	91	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. § From Bradford Share List.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Consolidated Telephone Construction and Maintenance 2/—4/-
National Electric Free Wiring, 17/6 paid, ¼—¾.

Oldham, Ashton, and Hyde Electric (£10 pd.), Ord., 15½—16.
Do. do. Pref. (£10 pd.), 10½—10¾.

* From Birmingham Share List. ¶ From Manchester Share List.

Bank rate of discount 4 per cent. (October 31st, 1901).

MARKET QUOTATIONS, Wednesday, December 11th.

CHEMICALS, &c.		This week.	Last week.	Inc. or Dec.
a Acid, Hydrochloric	per cwt.	5/-	5/-	..
a „ Nitric	per cwt.	22/-	22/-	..
a „ Oxalic	per cwt.	32/-	32/-	..
a „ Sulphuric	per cwt.	5/6	5/6	..
a Ammoniac, Sal	per cwt.	39/-	39/-	..
a Ammonia, Muriate (crystal) ..	per ton	£33 10	£33 10	..
a „ „	per ton	£90	£90	..
a Bleaching powder	per ton	£7	£7	..
a Bisulphide of Carbon	per ton	£15	£15	..
a Borax	per ton	£13	£13	..
a Bensole (90 %)	per gal.	7/-	7/-	..
a „ (50/90%)..	per gal.	5/6	5/6	..
a Copper Sulphate	per ton	£23	£23	..
a Lead, Nitrate	per ton	£24	£24	..
a „ White Sugar	per ton	£31	£31	..
a „ Peroxide	per ton	£27 10	£27 10	..
a Methylated Spirit	per gal.	2/6	2/6	..
a Naphtha, Solvent (90% at 160° C).	per gal.	5/6	5/6	..
a Potash, Bichromate, in casks..	per lb.	8d.	8d.	..
a „ Caustic (76/80%) ..	per ton	£24	£24	..
a „ Bisulphate	per ton	£35	£35	..
a Shellac	per cwt.	135/-	135/-	..
a Sulphate of Magnesia	per ton	£4 10	£4 10	..
a Sulphur, Sublimed Flowers ..	per ton	£6 5	£6	5s. inc.
a „ Recovered	per ton	£5 10	£5 10	..
a „ Lump	per ton	£5	£5	..
a Soda, Caustic (white 70 %) ..	per ton	£10 15	£10 15	..
a „ Crystals	per ton	£3	£3	..
a „ Bichromate, casks ..	per lb.	2¼d.	2¼d.	..

METALS, &c.				
b Aluminium Ingots, in ton lots	per ton	£148	£148	..
b „ Wire, in ton lots	per ton	£224	£224	..
b „ Sheet, in ton lots	per ton	£191	£191	..
p Babbitt's metal ingots.. ..	per ton	£75 to £125	£75 to £125	..
c Brass (rolled metal 2" to 12") basis	per lb.	7¼d.	7¾d.	¼d. dec.
c „ Tube (brazed)	per lb.	9d.	9¼d.	¼d. dec.
c „ „ (solid drawn) ..	per lb.	8d.	8¼d.	¼d. dec.
c „ Wire, basis	per lb.	7¼d.	7¾d.	¼d. dec.
c Copper Tubes (brazed) ..	per lb.	9¾d.	10d.	¼d. dec.
c „ „ (solid drawn) ..	per lb.	10¼d.	10¾d.	¼d. dec.
g Copper Bars (best selected) ..	per ton	£75	nominal	..

METALS, &c. *(continued.)*		This week.	Last week.	Inc. or Dec.
g Copper Sheet	per ton	£75	nominal	..
g „ Rod	per ton	£80	nominal	..
c „ (Electrolytic) Bars ..	per ton	£80	£82	£2 dec.
c „ „ Sheets ..	per ton	£88	£90	£2 dec.
c „ „ Rod ..	per ton	£82	£84	£2 dec
c „ „ H.C. Wire	per lb.	9¼d.	9⅝d.	⅜d. dec.
f Ebonite Rod	per lb.	8/-	8/-	..
f „ Sheet	per lb.	6/-	6/-	..
n German Silver Wire	per lb.	1/6	1/6	..
h Gutta-percha fine	per lb.	8/-	8/-	..
h India-rubber, Para fine	per lb.	3/5 to 3/7	3/5 to 3/7	..
i Iron, Charcoal Sheets	per ton	£18	£18	..
i „ Pig (Cleveland warrants) ..	per ton	43/1	42/9	4d. c.
i „ Forgings, according to size	per ton	From £11	From £11	..
i „ Scrap, heavy	per ton	47/6 to 50/-	47/6 to 50/-	..
i „ Wire, galvanised No. 8 ..	per ton	£10	£10	..
g Lead, English Ingot	per ton	£10 17 6 to £11	£11 5	dec
g „ „ Sheet	per ton	£13 10	£13 10	..
m Manganin Wire No. 28	per lb.	8/-	8/-	..
g Mercury	per bot.	£8 17 6	£8 17 6	..
d Mica (in original cases), small ..	per lb.	3d. to 9d.	3d. to 9d.	..
d „ „ „ medium	per lb.	1/9 to 2/9	1/9 to 2/9	..
d „ „ „ large ..	per lb.	3/3 to 7/3	3/3 to 7/3	..
p Phosphor Bronze, plain castings	per lb.	1/0½ to 1/3	1/0½ to 1/3	..
p „ rolled bars & rods	per lb.	1/1 to 1/4	1/1 to 1/4	..
p „ „ strip & sheet	per lb.	From 1/3	From 1/3	..
o Platinum	per oz.	£4 1	£4 1	..
p Silicium Bronze Wire	per lb.	10½d. to 1/0½	10½d. to 1/0½	..
i Steel, Magnet, acc'd'ng to desc'p'n	per ton	From £15	to £40	..
i „ „ in bars		£58	£58	..
g Tin, block	per ton	£115 to £116	£113 to £114	2 inc.
g „ foil	per lb.	1/6	1/6	..
n „ wire, Nos. 1 to 16	per lb.	1/7	1/7	..
p White Anti-friction Metals —				
"White Ant" brand	per ton	£35 to £65	£35 to £65	..
j Yarns, 2/10s Grey Cotton, on sp'ls	per lb.	7d.	7d.	..
j „ 6 lea. Flax	per lb.	5½d.	5½d.	..
j „ 8 ply 10 lbs. Russian ..	per lb.	4¾d.	4¾d.	..
j „ 10 lbs. Russian, single ..	per lb.	4½d.	4½d.	..
j „ 180 lbs. Jute rove	per ton	£10 2 6	£10 2 6	..
k Zinc, Sh's. (Vieille Montagne bnd.)	per ton	£22 10	£22 10	..

Quotations supplied by { *a* Messrs. G. Boor & Co. *b* The British Aluminium Co., Ltd. *c* Messrs. Thos. Bolton & Sons. *d* Messrs. F. Wiggins & Sons. *e* Messrs. Frederick Smith & Co.

Quotations supplied by { *f* India-Rubber, G.-P. and Teleg. Works *g* Messrs. James & Shakspeare. [Co., Ltd. *h* Messrs. Jackson & Till. *i* Messrs. Bolling & Lowe. *j* Messrs. Walter H. Hindley & Co.

Quotations supplied by { *k* Messrs. Morris Ashby, Limited. *m* Messrs. W. T. Glover & Co., Ltd. *n* Messrs. P. Ormiston & Sons. *o* Messrs. Johnson, Matthey & Co., Ltd. *p* The Phosphor Bronze Company, Ltd.

ACCUMULATORS AND ELECTRIC TRACTION SYSTEMS.

There are probably few subjects connected with electrical engineering upon which more divergent views are held than the question of the utilisation of accumulators in relation to electric traction systems. While the various merits of high speed and low speed engines, alternating and direct current systems of electricity supply, and other matters of cognate interest to the profession generally, have been pretty well thrashed out before various learned societies, and in the technical press, this question of the employment of accumulators under the conditions obtaining in electric traction systems in this country does not seem, up to the present, to have been placed on the firm basis of a standard practice. And on reflection this apparent want of unanimity as to the employment or otherwise of the class of apparatus in question is the more striking, having regard to the fact that the sweet unction that English engineers have been laying to their souls for many years past, anent their apathy in the field of traction apparatus, was the thought that after the Germans and Americans had finished spending the large sums of money which they so lavishly poured out on experiments, and had definitely arrived at the survival of the fittest, then—*then* would be the time to take advantage of the wheat which had been laboriously separated from the chaff, and to follow along lines which bitter experience had dictated to be the best. This being so, it is curious that the employment of accumulators on traction systems is so largely followed in America and on the Continent, and is only beginning to make headway in this country.

Storage batteries in connection with electric traction systems may be divided broadly into two classes :—

1. Where the battery is situated close to the power station, in which case its function would be purely and simply that of a "load leveller," and it would flatten out the curves of the output of the station by smoothing off the peaks and levelling up the hollows.

2. Where the battery is situated some distance away from the power station, either at some distributing centre or at the end of a feeder. In this case—while the battery would level up the load on its own section by discharging when any sudden demand for current was made, and be conveniently charged when the load went off and the volts rose—its chief and most important function would be as a potential regulator, thus effecting the saving of a considerable amount of capital outlay in copper, which would have been necessary for feeders if the battery sub-station had not been adopted, whereas by its means the heavy demands for current can, so to speak, be dealt with locally, being furnished by the battery instead of it being necessary to convey the current, in some cases it may be several miles, through a cable that must be of sufficient size to carry it without any undue drop in voltage. Where extensions of the system are decided on, battery sub-stations have in many cases proved the most economical way of meeting the new conditions. Take, as an example, the case of a spur line which it is proposed to extend in a direction away from the power house, or on which, owing to the growth of traffic, it is necessary to increase the number of cars ; this may mean the sinking of more capital in copper, or, if the extension is for any considerable distance, a new power house. A battery sub-station would in most cases be less in first cost than fresh feeders, and certainly cheaper than a new power house, and in the case of a tramway operating without batteries, would probably enable the existing plant to deal with the increased load with little further outlay than the cost of the sub-station.

It may be urged that a properly designed traction generator should be capable of standing heavy momentary overloads without detriment, which is, no doubt, true, but it is incontrovertible that steam (and therefore coal) is economised by operating at constant full load without violent fluctuation. In small traction stations for systems running from 10 to 25 cars, more particularly where the routes are at all hilly, the load may vary between 500 and 600 per cent., necessitating the running of sets which must be capable of taking these violent peaks without injury, and are consequently loaded most uneconomically during the period that elapses between them, whereas by the employment of a battery in parallel the variations can be enormously reduced. This means not only that the plant can be run throughout the day under the most economical conditions, but also that owing to the violent fluctuations of the load being removed from the generators and taken up by the battery, a smaller unit can be employed, resulting in a considerable saving of capital outlay.

As regards the use of battery sub-stations for keeping up the voltage of the line, it may be suggested that a booster would fulfil the same purpose, be cheaper in first cost and maintenance, occupy less space and require less attention, and, further, that feeder copper is a better investment than lead. Let us examine this contention in detail. The fact is sometimes lost sight of that a battery sub-station takes care of the local demands, that is to say, takes off the peak of the load in its neighbourhood, and the copper to the sub-station need, therefore, be calculated for only an average load and not a maximum, effecting a saving in first cost of copper, reducing copper losses, and enabling extensions to be carried from the sub-station only instead of, perhaps, the power station itself. The use of a booster for keeping up the voltage does not in any way reduce the fluctuations on the generating plant, but would accentuate them, because the drop in volts on the line would tend to reduce the rush of current due to the starting of the cars, whilst a booster, by keeping up the volts, would cause bigger rushes of current than if it were not employed.

Again, a breakdown of the generating plant would not entail an entire stoppage of the system if there were battery sub-stations, which unfortunate event would not be mitigated in any way by any number of boosters. Electric traction systems have in most instances competitors of various sorts for the privilege of carrying the travelling public, and cannot afford now, and will probably be still less able to do so in the future when their competition is recognised and steps have been taken to meet it, to allow public confidence in them to be shaken by anything approaching frequent breakdowns. Reliability is of the utmost importance, and the steps taken by American engineers to ensure that first, foremost, and beyond everything, the service for which they are responsible shall be as free from breakdown as human forethought can possibly make it, would, we think, be a revelation to many engineers on this side.

Not only is the boiler, engine and generating plant in the best practice in duplicate, but batteries of such a size are employed as to render a stoppage of the system a matter of extreme improbability. We have no wish to harp unduly on the American string, but the fact remains that there is hardly a traction plant of importance in the States that is not employing batteries. If it pays Jonathan, it ought to pay John.

For lighting the car sheds at night while the cars are being cleaned, moving the cars about the depôt, bringing home the late cars, and running the early morning cars, a battery serves a useful purpose, enabling the steam sets to be entirely shut down, and affording an opportunity for inspection and repairs, which would not otherwise be obtained. In small traction stations a battery of suitable size for this class of work would be a useful adjunct in the event of a breakdown of machinery, as it could give heavy discharges for short periods till repairs were effected, or another set got under way.

With three-phase transmission and rotary converters in sub-stations, the use of batteries enables the efficiency of the plant to be raised to a considerable extent. The rotary can be run at a uniform load, and need not therefore be capable of dealing with the maximum load, which would be taken by the battery. The starting of the rotary is also a simple matter under these conditions, the direct current end being supplied with current from the battery, and thus obviating any complicated devices or unnecessary auxiliaries.

In England, up to the present, the greatest activity in electric tramway development has, not unnaturally, taken place in the larger towns, and plant has, in many cases, been installed, which is capable of dealing with the very considerable extensions which are probable in the near future, that is to say, the size of the generating units is large for the present output of the station, and the sub-stations, where

such are employed, contain plant capable of dealing with a much greater output than is at present called for. Take, for instance, Glasgow, where the whole of the tramway system of the city is driven during a large portion of the day by one generating set, although four sets are installed.

In such a station there is a large margin of both engines and generators to cope with the fluctuations of the load, and it would seem probable that when it is necessary to run two sets during periods of extra heavy traffic, they must be uneconomically loaded. But in a tramway system as laid out in Glasgow, with rotaries in sub-stations, the advantageous use of batteries in connection therewith will, as the system extends, become apparent. They would reduce the amount of machinery running at the station, by taking the peaks, and would also enable the sub-stations to deal with a larger number of cars, and run at a steadier load, while they would allow of extensions to the outlying suburbs without any further outlay on copper between the sub-stations and the power house. In other words, the use of battery sub-stations would permit of the use of smaller units in the power house, or, with a given size of unit, would enable more cars to be run.

The practice of connecting a battery of such a number of cells as will give the average voltage of the power circuit at the point where the battery is located, in parallel with the load, seems to be rapidly disappearing in favour of a smaller number of cells discharging through a booster. The demands for current from the battery are, of course, extremely fluctuating in character, and at times are very heavy if the routes are hilly, the cars get bunched, or for other reasons. Consequently, just at the very time when the assistance of the battery output is most needed, its voltage drops, owing to the heavy calls upon it, and the object of its existence is to some extent nullified. This drop in volts could, of course, be remedied by putting down a battery of such a size as would give the output called for without discharging at a rate which would bring about a heavy drop in its voltage, but, in any case, a battery by itself across the mains is not so "lively" as a battery discharging through a booster. This enables a smaller size of battery to be installed, effecting a saving in capital outlay and—an important point in some cases—requiring less floor space. The fluctuations in load are taken up by the booster for charging the battery, thus reducing the time required for this operation at the end of the day. Moreover, the watt-hour efficiency of the battery is very considerably improved (by an extent which will more than compensate for the power required to run the booster), being as high as 85 to 90 per cent. when working under these conditions. This somewhat abnormal efficiency is due to the fact that, when working through a reversible booster on a traction load, the discharge is followed so rapidly by a charge that the increased voltage due to gassing is taken full advantage of, and the average E.M.F. per cell is more than 2 volts, even on a heavy discharge.

By this means the battery at the end of the day's run is practically fully charged and ready for the night load, and the heavy discharges taken from it have nothing like the exhausting effect which they would have if the old method of running the battery down were employed. The effect of the battery discharging through the booster has practically the same result as though the battery had no internal resistance. That is to say, the combination gives practically the same voltage at any discharge rate.

Another important innovation in this connection is the absence of any regulating cells. Several ingenious devices have been patented in the past to automatically cut regulators in and out as occasion demanded, but it cannot be said that in the traction field they have been a success, and by removing this weakness a distinct progress has been made. The regulators in a battery were always a weak point, due principally to the fact that the amount of work they were called upon to do differed from that performed by the rest of the battery: to treat the battery as a whole, and to maintain a constant voltage by an automatic booster, removes one difficulty at any rate.

In these days when the question of cost is so keenly discussed, and with numerous examples of what has been done in this direction constantly appearing in the Press, it seems somewhat strange that fuller advantage has not been taken of the economies which a battery offers in this connection. It may be that as this branch of electrical engineering emerges more fully upon that phase of activity of which it at present gives such bountiful promise, the extension of tramways in all directions will create conditions which can only be met satisfactorily—as they have been in other countries—by the extensive employment of batteries.

ELECTRIC TRAMWAYS ON THE CONDUIT SYSTEM.

Bournemouth and London.

The slot conduit form of construction is now coming into great prominence for the construction of tramways in some parts of this country. For some time past this method of construction has been recognised, and has been working admirably in the States and in various Continental cities; but, apart from the pioneer installation that was at Blackpool, it is only within the last few months that any particular attention has been given to this system in England. From the reports which have been published in the Electrical Review during the past month or two, our readers will have learned that Messrs. J. G. White & Co., Limited, of 22A, College Hill, Cannon Street, E.C., have had placed in their hands two important contracts for conduit track construction, viz., one from the Bournemouth Corporation, for about 3 miles of conduit, and one from the London County Council for about 16 miles of conduit. Although the conduit system is to be installed by both these authorities, each installation will be of particular interest, on account of the difference in the details.

In the case of Bournemouth, first of all, the side-slot construction will probably be used, that is, the slot, instead of occurring in the middle of the track, will be coincident with one of the wheel-rail grooves. At the slot points the slot will be deflected to the central position. The width of slot will be 1 in. and $1\frac{1}{8}$ in., the latter occurring on the curves.

At Bournemouth, also, for the first time in this country, will be instituted a combination of the conduit and overhead trolley construction. It is proposed to instal about 14 miles of overhead structure at the extremities of the conduit tracks, the permanent way for this work being also entrusted to Messrs. J. G. White & Co., Limited. A special point of interest here will be the mechanism by which the plough is raised from or lowered into the conduit. The apparatus will closely resemble that used in Paris and other French cities.

In the case of the London County Council contract, there will be no overhead construction, and the whole 16 miles (which, by the way, is the first portion of the large system of electric tramways eventually to be installed) will be of the centre-slot type. In this case the width of the slot will be $\frac{3}{4}$ in.

We have no doubt that other cities in the provinces which do not favour trolley construction for central or congested thoroughfares, will be influenced to a considerable extent by the examples which have been set by London and Bournemouth.

SHALLOW UNDERGROUND TRAMWAYS.

The joint report by the tramways manager and the electrical engineer of the London County Council on the construction and working of the Boston, U.S.A., subway, and the Rapid Transit subway, now under construction in New York, together with an addendum by Mr. J. Allen Baker, vice-chairman of the Highways Committee, has been published, and we purpose here giving a summary of that very important document; the subject matter is dealt with critically on another page.

The gentlemen who were deputed by the Council to visit various cities in the United States and Canada, to inquire into the latest developments of electrical traction generally, confine themselves entirely to the construction and working of the subways in the above-mentioned cities, leaving the result of their investigations with regard to electrical traction to be submitted to the Committee in a separate report.

Before describing the subway in Boston, a brief history is given of the events leading up to its construction. In about the year

1891, the traffic in the streets of Boston had become so congested that it became imperative that some action should be taken, if possible, to afford relief.

When it is remembered that in American cities, cabs, omnibuses, and other vehicles for the conveyance of passengers, except street cars, are practically unknown, it is not to be wondered at that this condition of things became unbearable. An Act was therefore passed by the Massachusetts Legislature, establishing a Commission for the purpose of "providing and regulating transportation in and around the city of Boston."

The conclusions the Commissioners arrived at were, amongst others, as follows:—

1. That a new and thorough re-adjustment of street lines should be made, so as to furnish new and adequate means of transportation for foot passengers, teams, and surface cars, through the busy section of the city.

2. That the street railways should be re-organised by taking advantage of the proposed new streets, and by the building of a tunnel under a portion of Boston Common and Tremont Street, through which the cars to the southern and western portions of the city should be run.

3. The erection of two complete lines of elevated railways.

In Boston the London County Council representatives found that the tunnel, or subway, under a portion of the "Common," as well as Tremont Street, had been constructed, and that the elevated railway lines were erected and in operation. The only recommendation not actually carried out, so far as they were able to ascertain, was that with regard to the new streets.

The responsibility of building the subway was vested in a Commission appointed by the Governor of Massachusetts in 1894. In the Act passed by the Legislature authorising its construction, the length of the subway was to be some five miles of single track, part being for four tracks and part for two tracks.

After a considerable amount of preliminary inquiry, the construction of the subway was commenced on March 28th, 1895, at the Public Gardens, where an incline about 100 yds. long carries the surface lines into the tunnel, and on September 1st, 1897, the first section to Park Street, about 1,300 yds. in length, was opened for public service. The whole subway, as it now exists, was completed in three years and 4½ months, the official date of completion being given as August 15th, 1898.

The Act required "that all streets and places under or near which a subway is constructed, shall be open for traffic between 8 a.m. and 6 p.m.," and this requirement, it is said, has been strictly complied with.

The subway is entered from Boylston Street by means of the incline in the Public Gardens before mentioned, and passing under the edge of Boston Common to Tremont Street, is joined by a branch subway, coming from Pleasant Street, where another incline leads to the surface. From the junction, the subway continues under the Tremont Street side of the Common to Park Street, which is the centre of the system, and where there is a loop terminus. From Park Street, the subway is carried directly under Tremont Street to Scollay Square, and by means of bifurcation under Hanover Street on the one hand, and Cornhill on the other, to a junction under Washington Street. The subway continues under Washington Street to Haymarket Square, and immediately afterwards rises, by an incline, to Causeway Street, where it connects with both the surface and elevated lines.

The methods adopted for building the subway were of three distinct types. In the first, the side walls and the arch are of masonry, a single wide arch covering the whole subway. In the second, there are two distinct tunnels side by side, each built of masonry. In the third, upright steel columns for the side walls, and transverse steel girders for the roof are used, with masonry and concrete around and between them. The two former methods are practically identical with an ordinary railway tunnel. The latter method is being adopted almost entirely in the New York subway, which we refer to later on.

The open inclines leading to the surface roads have granite walls, and are protected by railings.

The standard height of the roof is 14 ft. clear above the service of the rails, and the roof is generally about 3 ft. below the street surface. In some places, however, the subway is considerably lower than this.

One of the most important differences between a shallow subway and a deep level tube, from the point of view of the travelling public, is well illustrated at Boston. Instead of having to descend a very great number of steps or enter a lift in order to reach the cars, passengers use a short, well-lighted stairway, having from 25 to 30 steps. Persons can thus descend to the platforms or ascend to the street in a very few seconds. In the opinion of the London experts, this single feature is in itself one of the principal factors in the great popularity of the subway. There are five stations in Boston.

The level of the platforms is generally about 1 ft. above the surface of the rails, and they are as long and wide as circumstances would permit, in order to prevent overcrowding.

In all cases the principle of island platforms has been adhered to, and separate entrances and exits are used. The sides of the subway at and near the stations are lined with white glazed bricks, and the tunnel generally is whitewashed throughout. The overhead trolley system is used for all the Boston Street cars, while the third rail system is used for the cars on the elevated roads. These systems are continued through the subway, so that one set of tracks (for the surface cars) has the overhead wire, and the other (for the elevated cars) has the third rail. All the cars are "single-deckers," as is common in America. This type of car is practically compulsory for shallow subways, both in order to reduce the height of the tunnel, and also to prevent any danger to passengers on roof seats.

The Commission, having obtained further powers, is now engaged in extending the subway under the Boston Harbour, to connect the surface lines in the district of East Boston with the main system. This will add a further three miles, making the whole subway about eight miles of single track.

The subway was built at the expense of the city, and the Boston Railway Company, which owns both the surface and the elevated lines, pays a rent to the city for the use of the subway of five cents (2½d.) for each single journey per car passing through, with a minimum payment amounting to 4⅞ per cent. on the cost of construction. By a contract made in 1896 the city leased to the company the exclusive right to use the subway for a term of 20 years. The railway company laid the tracks in the subway, and bears the cost of all repairs other than those made necessary by the Act of God, mob riots, falling or settling of buildings, &c., which are paid for by the city.

At the time of the visit of Mr. Rider and his colleague the works were quite completed, and they found that not only were the surface cars running through, but trains from the elevated railway as well. There was no sense of stuffiness, and although the day was hot, the temperature inside the subway was pleasantly cool. At the same time, the difference in the temperature was not so great as to be likely to cause chill or discomfort by the sudden change.

The subway was well lighted by incandescent lamps, besides which a considerable amount of natural light was obtained. This was especially noticeable at the stations. The Englishmen were also impressed by the comparative quietness of the subway, both as regards the traffic inside, and the noise which might have been expected from vehicles passing overhead. When in the streets, also, no noise whatever was apparent from the subway, although cars were continually passing close under one's feet.

There is an enormous amount of traffic through the Boston subway. It is stated that the passenger traffic at the Park Street station ranks amongst the largest in the world.

The number of cars running in each direction is about 250 per hour, or about 4,000 in each direction per day of 16 hours. On the Central London Railway there are only 350 trains per day in each direction. These, of course, are trains consisting of about five carriages, but even allowing for this, the traffic in the Boston subway is considerably greater than in the "twopenny tube."

The London gentlemen agree that a frequent service of single cars is much preferable to a train at longer intervals. The passengers are taken away almost as soon as they reach the station platforms, and are delivered to the street at a steady rate, instead of being discharged in crowds every few minutes.

In New York they found a system of subways in actual construction.

A Rapid Transit Commission was appointed by the State as far back as 1875, and the outcome of its labours was the present elevated railroad system. Another Commission was appointed in 1894, with powers to fix a route for a railway, prepare the necessary plans and specifications, and call for contractors to build and operate for a period of 50 years. After much careful consideration, and weighing of the advantages and disadvantages of deep tunnels and shallow subways, the latter was decided upon by the Commission, and as being most likely to afford the best facilities for rapid transit to the citizens of New York. The result is the subway now under consideration.

The city is to pay the contractor the amount of his bid for construction, while he, in turn, is to pay, as rental, the interest on the bonds issued by the city to provide the required funds, and, in addition, 1 per cent. as sinking fund. The contractor provides equipment, power houses, and generating machinery, which the city is to purchase at the conclusion of the lease at a valuation to be determined then by arbitration.

Under this arrangement the city obtains the benefit of immediate construction of a rapid transit railway, and without burden on the ratepayers, because the contractor is to pay the interest on the investment. It is stated that at the end of about 45 years the sinking fund will have redeemed the principal, after which the whole rental will be net profit. On the conclusion of the lease it is expected that the City will be able to make a new one on much better terms.

The general scheme of the subways is as follows:—

Starting with a loop round the General Post Office, a four-track road is taken direct north to the Grand Central station in 42nd Street. It then turns west along 42nd Street to Broadway, and proceeds under Broadway to 104th Street, a distance of seven miles. Here the four tracks divide, a double track continuing along Broadway to Kingsbridge, and another double track easterly under the Harlem river to the Bronx district. Each of these branches is seven miles long, making a total length for the whole system of 21 miles, seven miles being four-track and 14 miles double track. The northerly ends of the double track lines will be elevated structures for a combined distance of about five miles, while all the remainder will be underground.

The design of the structure of the subway is somewhat as follows:—

Instead of the arched roof and the massive masonry sidewalls of an ordinary underground railway, the plans of the Rapid Transit Commission call for a structure rectangular in shape, and built in an open trench. On a concrete bottom will be erected, at intervals of 5 ft., running across the line of street, frames of steel beams, securely rivetted together. Between these frames, or ribs, will be built a concrete wall and a concrete roof of sufficient thickness to enclose the steel structures entirely. In addition to the side walls thus formed, the roof will be supported by rows of light steel columns between the tracks.

In order to make the subway entirely waterproof, layers of roofing felt and asphalte will be used to keep out water wherever

the subway is carried below the ground water level. It is intended to keep the subway as close to the surface of the street as the roof will permit. The portions of the stations which lie beneath the footpaths will be roofed with glass, so that as much sunlight as possible will be obtained, and the stations being lined with decorated tiles, and the subway having a flat roof, the whole structure will suggest to the public what it really is, viz., *a covered way*.

As before mentioned, part of the subway will have four tracks. The two centre tracks will be used for an express service, with stations 1½ miles apart, and it is expected that a speed of about 30 miles an hour will be obtained. On the outer tracks the stations will be at much more frequent intervals, averaging four to the mile, and the trains will run at a speed of about 14 miles per hour.

This will necessitate two types of stations, one with platforms on the outside of the outer tracks, at which the local trains only will stop, the express trains running through the centre tracks, and the other with outer platforms for the local trains only, and island platforms for either express or local trains. At these latter stations the subway is depressed sufficiently to allow of a bridge under the roadway over the four tracks, with stairways leading to the various platforms.

The arrangements which have been made to eliminate crossings and switching at the termini are quite a feature of the whole design. By means of loops, and, in places, lowering the express tracks beneath the local tracks, the trains will be operated continuously without any cross-switching or shunting whatever.

In many of the streets the subway has to be cut through the solid rock, while in others soft sand only is found. In Park Row the whole roadway is being undermined without any disturbance to the traffic, and when it is stated that there are four tracks of conduit electric cars on the surface, and that the subsoil is entirely sand, some idea of the difficulties of the work and the skill of the engineer may be obtained.

The contract price for the construction of the New York Subway was $35,000,000 (£7,000,000). Its entire length is 21 miles, which makes the cost about $1,666,000 (£333,000) per mile. These figures do not include the cost of rolling stock or power houses. The work of construction was begun on September 1st, 1900, and it is expected that it will be completed in the early part of 1904.

From the foregoing, it will be seen that the subway in Boston answers the purpose solely of relieving the street traffic in a congested area, by taking the surface cars underground where traffic is great, the cars coming to the surface again where the traffic is less dense. The subway in New York is to be entirely self-contained, quite apart from the surface cars, in the same way as the Central London Railway, with the important difference that it provides for express as well as local traffic.

It appears to the County Council Commissioners that the problem in London will never be satisfactorily solved until the tramways north and south of the River Thames are linked together. London has suffered much from want of intercommunication, on account of its tramway system being completely divided by the river.

It appears to them, also, that by the construction of shallow underground subways in London, two important objects would be gained, viz.:—

(1.) A method of linking up existing tramways by taking surface cars underground through congested, and, what might be termed, prohibited areas.

(2.) A provision for pipes, cables, wires, &c., which would obviate the continual breaking up of the streets.

With regard to (1) the Council, after much anxious thought and attention, is about to commence the reconstruction for electric traction of the whole of the existing lines in South London, and the Highways Committee is considering the possibility of the electrification of the northern lines. When this work is carried out, enormous advantage will accrue to London. Still, the difficulty will remain of the want of intercommunication between north and south. They think the solution of this question would be largely assisted by the construction of subways in congested districts, and through prohibited areas, as has been successfully done in Boston.

With regard to (2), many proposals have, from time to time, been made with a view of obviating the nuisance. In some cases, where the Council has constructed new streets, subways for the purpose of accommodating pipes, &c., have already been made. This, however, only touches the fringe of the problem, and any suggestion to make subways under existing principal thoroughfares solely for this purpose would, doubtless, be vetoed on account of the cost. By constructing subways which could be used for passenger transit purposes, as well as for taking pipes, &c., a considerable revenue would be earned, sufficient, in the opinion of Messrs. Rider and Alfred Baker, to warrant the heavy outlay.

Apart from these purposes, they believe that shallow subways, such as they saw both in Boston and in New York, are, in many respects, preferable to deep level railways. The absence of elevators, and the ready access from the street to the stations, and *vice versâ*, by means of short stairways, render them particularly useful to those who wish only to ride short distances.

The ideal form of transit, in their opinion, is the one proposed in New York, viz., a subway, easy of access from the street, catering for express and local traffic.

However, if it be not possible to reach the ideal, they believe that the condition of things can be vastly improved by a system of subways, which would have regard to the needs of London as a whole, rather than by the construction of a subway to meet the requirements of any particular district. In their opinion the true solution of the question does not lie in the building of deep level railways, or, for that matter, subways, as separate schemes entirely disconnected from each other, but rather in a complete system, which should be carefully conceived, and carried out from the first with a view of intercommunication between all parts of the metropolis. Unfortunately, however, the deep level railways, already authorised as separate schemes, render it extremely difficult, if not impossible, to devise a complete system, such as London needs.

There is, however, one definite proposal which they venture to submit as being quite practicable, and, at the same time, highly desirable. It is that a subway should be constructed from the level of the Victoria Embankment, at a point close to Waterloo Bridge, under Wellington Street, across the Strand, and under the new street now being made by the Council from the Strand to Holborn. Passing under Holborn to Southampton Row, it would connect by an incline to the surface lines in Theobald's Road. The Council has already decided to apply to Parliament for powers to construct a surface tramway along the Victoria Embankment, and if the application be successful, a connection between the tramway and the subway could be effected at Waterloo Bridge, where the physical formation of the ground would enable it to be made without any gradient.

If this proposal were carried into effect, communication would be obtained from both Westminster and Blackfriars Bridges to the greater portion of the northern tramway system. Short connecting lines over the two bridges would only then be required to link up the southern system.

Probably the most important factor to be considered in deciding upon any system of subways is that of cost. Messrs. Rider and Baker have taken a great deal of trouble to arrive at a satisfactory basis on which to estimate, and while the cost of subway construction in London is not necessarily the same as in America, still they think that the figures obtained in Boston and New York will be a valuable guide. Both in Boston and in New York the subways are constructed partly for four tracks and partly for two tracks. The cost of a four-track subway is, of course, not nearly double the cost of a two-track, although the amount of actual excavation may be very nearly twice as much. They have assumed that a four-track subway will cost about one-third more than a two-track subway, and on this basis the Boston Subway works out at about £425,000 per mile for a two-track subway. In New York the matter is rather more complicated, since about five miles of the extreme ends of the lines will be an elevated structure, and not a subway, as was mentioned earlier in this report. After making due allowance for this, the cost in New York works out at about £350,000 per mile for a two-track subway.

They think this latter figure may be taken as a rough guide for a large proportion of the proposed subway work in London. While in London the difficulties with cellars and pipes will doubtless be much greater than in New York, yet labour there is much more expensive than in this country, and the great quantity of rock which had to be removed must have added considerably to the cost.

Taking the New York figures, therefore, as a basis, and assuming that the type of construction adopted in London would be similar to that in New York, which they should strongly recommend, the cost of the scheme they have suggested works out at about £282,000. This figure, however, does not include any sum for the purchase of vaults, cellars, or any other vested interests, or for the addition of pipe galleries to the subway, or for the transfer of pipes to them.

Woolwich, Deptford and Lewisham.—The L.C.C. have addressed a communication to the M.B.C. of Woolwich on the subject of the widening of thoroughfares connected with the proposed construction of a tramway from New Cross to Eltham, expressing their thanks to the Council for its decision to consent to the proposed tramways and to make the necessary contribution of one-third of the net cost of the street widenings in Woolwich. The L.C.C. have also been in communication with the Deptford and Lewisham Councils, with the result that, whilst those Councils have consented to the tramway, they have declined to make any contribution towards the cost of the street widenings. It has occurred to the L.C.C. Committee that probably Lewisham declined to make the contribution because the improvements within that borough were estimated to cost no less than £144,300, and the L.C.C. Committee therefore, after a full review of all the facts, have decided to advise the Council to amend the scheme, in order that it may for the present extend merely from New Cross Road to High Street, Lewisham. This will reduce the cost of the improvements in Lewisham to £34,500, instead of £144,300, and it is hoped that this amended scheme will be more acceptable, and that the M.B.C. will accordingly see its way to make the necessary contribution. The L.C.C. Committee regret the necessity of abandoning for the present the Woolwich portion of the scheme, especially as the M.B.C so readily acceded to the County Council's proposals, but trust tha the M.B.C. will realise that there was no alternative to the adoption of this course.

The Air Brake in the United States.—"The appalling death rate which is to be charged to the account of the various street railway systems of the country would be largely reduced if every car, particularly the large double truck cars, should be equipped with a modern air brake. This device is already in use on thousands of cars, and has demonstrated its ability to prevent accidents in innumerable instances."—*Municipal Journal and Engineer, (U.S.A.)*

Clocks for Cars.—The City of St. Louis, Mo., has struck out on quite original lines, as they appear to us, for an ordinance has been passed whereby the street car companies must place clocks in their cars.